Delta RMP Joint Technical Advisory and Steering Committee Meeting
October 18, 2016 9:30 am – 4:30 pm

Delta Stewardship Council Building

980 9th Street, 2nd Floor, Room A

Sacramento, CA

Conference video link:
https://deltacouncil.webex.com/deltacouncil/onstage/g.php?MTID=e3e97c808572c8b70659470d83a9e5796
Call-in: 1-877-402-9753
Access Code: 1882129

Agenda

1.	**Introductions and Review Agenda** Introduce TAC and SC members, establish quorum, and explain goals of the meeting		9:30 Brock Bernstein
2	**Decision: Approve Meeting Summary from July 20, 2016 and Confirm/Set Next Meeting Dates** <u>Desired outcomes:</u> • Approve meeting summary • Confirm next meeting date for TAC is December 13, 2016; SC is in January 26, 2017 • Select a date for spring SC meeting: May 2, 3, 4, or 5.	7/20/16 SC Mtg Summary RMP Decision Record (Excel Spreadsheet)	9:35 Brock Bernstein
3.	**Informational: Celebrating the success of the DRMP - a historical timeline and achievements to date** A recap of the DRMP development process, a timeline, and achievements.	None	9:45 Linda Dorn Adam Laputz
4.	**Discussion: TAC feedback on the approved Charter** The SC is interested in hearing feedback from the TAC on the approved charter, particularly the section on roles and responsibilities. It is important to agree on the roles of the SC and TAC prior to the multi-year planning session.	None	9:55 Stephen McCord
	Begin Multi-Year Planning Session		
5.	**Information: Overview of Multi-Year Planning Process** An overview of the goals of the MYP process will be given.	Memo describing the multi-year planning process **See Page 18**	10:10 Philip Trowbridge

6.	**Discussion: Report Out of Major Findings from DSP External Review** The Delta Science Program is coordinating an external review of the Delta RMP. The initial findings from the review will be presented and discussed; and the process for addressing the findings will be outlined. <u>Desired outcomes:</u> • Understanding of External Review findings and discussion of next steps. • Feedback on External Review from others who attended.	**See Page 25** Initial Report from the External Review Panel Memo describing the process for responding to the report	10:20 Sam Harader Adam Laputz Linda Dorn
7.	**Decision: Agree on Strategic Revisions to the Monitoring Design, if any** The Monitoring Design is a guiding document for the Program. The purpose of this agenda item is to identify any high-level revisions, such as changing the assessment questions or focus areas, based on recommendations from the DSP External Review. <u>Desired outcomes:</u> • Agreement on changes to the Monitoring Design, if any.	None	11:20 Phil Trowbridge
8.	**Discussion: Report Out on Outcomes from Nutrient Monitoring Workshop** On 9/30/16, the Delta RMP held a workshop to determine nutrient monitoring gaps and "no regrets" actions to fill those gaps. The options that were identified at the workshop will be presented. Desired outcomes: • Understanding of workshop outcomes as they relate to multi-year budget planning and priorities.	**See Page 47** Nutrient Monitoring Workshop Report	12:00 Phil Trowbridge

9.	**Discussion: Goals and Process for Revising the List of Pesticides** The Steering Committee has requested that the list of pesticides in the Monitoring Design be updated. The Coordinating Committee would like this process to be complete by the spring to be ready for the FY17/18 workplan. We will take advantage of having the TAC and SC at the same meeting to clarify the goals and process for revising the list. Desired outcome: • Agreement on the goals and process for revising the list of pesticides in the Monitoring Design	**See Page 126** 9/20/16 TAC Mtg Sum Slides for Proposed Process to Update Pesticide List	12:15 Stephen McCord
	Lunch break – Bring $5 cash is you want to join a pizza order.		12:30
10.	**Discussion: Review and Update Table of Upcoming Management Decisions** Last year, the SC identified upcoming management decisions. The table will be reviewed to determine if there are critical data that the Delta RMP could generate to inform these decisions. <u>Desired outcome:</u> • Review of table and input on whether any revisions are needed.	MYP Memo for Item 5	1:00 Philip Trowbridge
11.	**Decision: Agree on Planning Budgets for FY17/18 and Out-Years** Discuss budget projections and establish planning budgets for FY17/18, FY18/19, and FY19/20 that reflect priorities and available funds. In the beginning of 2017, the TAC will convene subcommittees to develop technical projects for the FY17/18 Detailed Workplan. Therefore, SC should establish priorities and budgets for each focus area (e.g., pesticides, nutrients, mercury, and pathogens) so the TAC has clear direction relative to these elements of the Workplan. <u>Desired outcomes:</u> • Agreement on planning budgets and priorities. • Clear direction to the TAC on FY17/18 budgets and priorities for each program element.	MYP Memo for Item 5	1:30 Brock Bernstein
	End Multi-Year Planning Session		

	Short Break		3:00
12.	**Decision: Approve List of "SEP Eligible" Projects** The Delta RMP has been approved as a Supplemental Environmental Projects Funds Administrator. To efficiently match up Delta RMP projects with settlements, the SC should approve a list of projects that are priorities but are unfunded. As a starting point, the list will include unfunded monitoring tasks from the Monitoring Design as well as proposed projects that were recommended by subcommittees but were not funded in FY16/17. Desired outcomes: • Approve a list of Delta RMP projects for SEP funding. The list can be updated by the SC at any time.	**See Page 139** Memo on SEP Process and Projects	3:15
13.	**Planning for How to Use Up the Balance of SWAMP Contract Funds** <u>Desired Outcome</u>: Decide on how to utilize SWAMP Contract funds for toxicity testing before these funds expire on June 30, 2017.	**See Page 158** Memo on SWAMP Contract Funds	3:35 Patrick Morris
14.	**Plus/Delta and Plan Science Update for Next Meeting.**		4:00 Brock Bernstein
15.	**Adjourn**		4:30

Supplemental Materials

Page 162 Delta RMP Financial Report for the Period Ending 8/31/16. The Finance Subcommittee met on 9/29 and has reviewed this memo. It will not be discussed by the SC due to time constraints.

Page 178 Action Item and Deliverables Stoplight Reports

Page 187 Summary of Prop 1 Proposal for Mercury Monitoring

- USGS High Frequency Sensor Report (will be sent under separate cover)

Materials for Agenda Item 2

Record of Decision for the Delta RMP Steering Committee

Number	Date	Decision	Meeting Summary Link	Type	Yes	No	Abstain
2016-1	04/25/16	Starting on April 25, 2016, minutes from the Steering Committee meetings should reflect only major discussion points, decisions, and action items.	FINAL	Consensus			
2016-2	04/25/16	ASC staff will provide a schedule for receiving comments when they send out draft minutes.	FINAL	Consensus			
2016-3	04/25/16	For the completion of more significant action items, a brief update will be given in the stoplight table describing the outcome of the item.	FINAL	Consensus			
2016-4	04/25/16	The TAC co-chairs will prepare a short summary of Delta RMP preliminary monitoring results/activities for the SC agenda package for each meeting. This item will not be distributed on lyris.	FINAL	Consensus			
2016-5	04/25/16	Approve the FY16/17 budget of $1,043,030 to complete the FY16/17 Detailed Workplan	FINAL	VOTE	11	0	0
2016-6	04/25/16	Retract the RMP fee increase of 2.5% for FY16/17 that was previously approved in December 2015.	FINAL	VOTE	10	0	1
2016-7	04/25/16	Allocate $20,000 from undesignated reserve funds to FY15/16 for possible pathogen trigger follow-up studies.	FINAL	VOTE	11	0	0
2016-8	04/25/16	SFCWA funding for FY15/16 ($100,000) will be initially credited to the FY15/16 budget, which will create a surplus of $100,000 for the FY. Then the surplus $100,000 will be transferred to the Undesignated Funds Reserve. Finally, the $100,000 will be re-allocated from Reserve to the FY16/17 budget. The next contribution from SFCWA (scheduled for April 2017) will be allocated to the FY17/18 budget.	FINAL	VOTE	11	0	0
2016-9	04/25/16	The TAC nominates the TAC co-Chairs. The SC confirms TAC co-Chairs and authorizes the payment of co-chairs, if TAC co-chair is a paid position.	FINAL	Consensus			
2016-10	04/25/16	ASC will provide a detailed financial memo to the Finance Subcommittee, including the internal accounting reports used to prepare these documents.	FINAL	Consensus			
2016-11	04/25/16	The decision was made not to use the MOA for all entities participating in the program (i.e., not all participants need to sign/ approve/ modify changes).	FINAL	Consensus			
2016-12	07/20/16	Meeting minutes from April 25, as amended, were approved.	DRAFT	Consensus			
2016-13	07/20/16	QAPP was approved upon the condition that there are no significant changes requested by the SWAMP QA officer. If significant changes are requested, the SC will be informed by e-mail.	DRAFT	VOTE	10	0	2
2016-14	07/20/16	Communication Plan approved	DRAFT	VOTE	12	0	1
2016-15	07/20/16	Charter as amended approved	DRAFT	VOTE	12	0	2
2016-16	07/20/16	Transfer surplus from FY15/16 to the Reserve. Revise ledger.	DRAFT	VOTE	9	0	5
2016-17	07/20/16	Use SEP funds to pay for projects that have been reviewed and approved by the SC	DRAFT	VOTE	12	0	2
2016-18	07/20/16	Fees for FY17/18 will have a zero percent increase from FY16/17 for budgetary planning purposes for the October 18th SC meeting. The SC will determine the final FY17/18 fees at the January SC meeting.	DRAFT	Consensus			
2016-19	07/20/16	Move forward with nutrient monitoring workshop planning.	DRAFT	Consensus			

Materials for Agenda Item 5

DATE: October 8, 2016

TO: Delta RMP Steering Committee and Technical Advisory Committee

FROM: Philip Trowbridge

RE: Overview of Multi-Year Planning Process and Tools

Background

Multi-year planning helps the Delta RMP to be cost-effective though identifying strategic, long-term partnerships and opportunities to leverage and/or augment existing funding. It keeps the program relevant to upcoming decisions and provides direction to the TAC and subcommittees for the development of the annual Detailed Workplan. The multi-year planning meeting fits into the Delta RMP budget process as follows:

- October Multi-Year Planning Meeting: SC and TAC hold a joint meeting to establish planning budgets for each focus area (e.g., pesticides, nutrients, and mercury) for the next three years that reflect priorities and available funds.
- November-March: The TAC convenes subcommittees to develop technical projects for the next fiscal year based on the priorities and planning budgets set in October.
- January: SC makes final decision on fees/revenue for the next fiscal year. In July, the SC decided to keep fees in FY17/18 the same as for FY16/17 for discussion purposes at the October meeting.
- February-March: ASC prepares a Detailed Workplan and Budget for the next fiscal year which is reviewed by the Financial Subcommittee.
- April: SC approves the Detailed Workplan and Budget for the next fiscal year.

Process for the October 2016 Multi-Year Planning Meeting

Step 1. For the first part of the meeting, the group will discuss recent reports that are relevant to potential changes to the Monitoring Design:

- Initial Report from the Delta Science Program's External Review Panel
- Outcomes from the 9/30/16 Nutrient Monitoring Workshop
- TAC proposed process for updating the list of pesticides in the Monitoring Design

Step 2. After lunch, SC and TAC will review the table of upcoming management decisions and information needs to inform these decisions. This step is important to keep the Program relevant to management decisions.

Step 3. The SC will review the multi-year planning budget table which lists options for Delta RMP funding in each focus area and shows prior year budget allocations. The range of costs listed for each option were compiled using the most recent information based on the Monitoring Design, the Nutrient Monitoring Workshop report (see Item 8), projects developed for SEP funding (see Item 12), and the Prop 1 proposal for mercury monitoring (see Supplemental Items at end).

The sheet already contains the costs in FY17/18 and beyond for the Prop 1 mercury project, planned communications products, and core functions. However, the Steering Committee will need to fill in the rest of the sheet with planning budgets for the various projects while staying within the total revenue of $1,056K. The allocations set at this meeting are non-binding and only for planning purposes. The actual budgets for each year will be in the Detailed Workplan and Budget that is prepared in the spring. However, the planning budgets are helpful to the TAC and ASC staff to understand approximately how much funding might be available for different focus areas and the SC′s priorities.

To assist the SC and TAC with this process, the following briefing documents are attached:

- Table of Current and Anticipated Management Decisions, Policies, and Actions by the Regulatory Agencies that Manage Delta Water Quality
- Multi-Year Planning Budget spreadsheet. For details on any of the projects listed on this sheet, please refer to the following materials:
    -

Current and Anticipated Management Decisions, Policies, and Actions by the Regulatory Agencies that Manage Delta Water Quality

Decisions, Policies and Actions	Lead Agency	Timing	Delta RMP Role To Date
Pesticides/Toxicity			
Central Valley Diazinon and Chlorpyrifos Basin Plan Amendment	CVRWQCB	SWRCB approval in 2015 EPA approval 2016	Regional data to track mgmt. action impact
Chlorpyrifos Regulations: (1) DPR restricted use material, effective May 2015 (2) EPA announced potential phase out in 2016	DPR, USEPA	2016	Regional data to track mgmt. action impact
Central Valley Pyrethroids Total Maximum Daily Load and Basin Plan Amendment	CVRWQCB	Hearing in Feb 2017 Monitoring starting in 2019	Regional data for baseline (pre-TMDL)
UCD Developing Water Quality Criteria for Oxyfluorfen, Prometryn, Simazine, Trifluralin, Fipronil	CVRWQCB	April 2017	Regional data for background
Toxicity Policy: New state plan on effluent and receiving water toxicity	SWRCB	2016	
Statewide Framework for Urban Pesticide Reduction (part of STORMS[1])	SWRCB	2018	Regional data for baseline (pre-action)
Nutrients			
San Francisco Bay Nutrient Science Plan	SFBRWQCB	January 2016	Optimizing monitoring designs
Central Valley Nutrient Research Plan	CVRWQCB	Summer 2017	Optimizing monitoring designs
Harmful Algal Bloom Waterbody Posting Decisions by Public Health Agencies	Various	Ongoing	
Proposed Policy for Nutrients in Inland Surface Waters	SWRCB	2017	
Biological Integrity Policy for Wadeable Streams	SWRCB	2017	
Mercury			
Statewide Reservoir Mercury Total Maximum Daily Load	SWRCB	June 2017	
State-Wide Mercury Water Quality Objectives	SWRCB	Spring/Summer 2017	
Delta Methylmercury Total Maximum Daily Load	CVRWQCB	Phase I review by Oct. 2020 Phase II start by Oct. 2022	Regional data for TMDL review, DPR model

[1] Strategy to Optimize Resource Management of Storm Water (STORMS)

Decisions, Policies and Actions	Lead Agency	Timing	Delta RMP Role To Date
Pathogens/Bacteria			
Drinking Water Policy and Basin Plan Amendment	CVRWQCB	2013	Regional data to implement Basin Plan
State-Wide Bacteria Objectives	SWRCB	2016	
Chemicals of Emerging Concern			
Chemicals of Emerging Concern Statewide Pilot Monitoring Program Development in Central Valley	SWRCB	2017	
Selenium			
North SF Bay Selenium TMDL	SFBRWQCB	Completed in 2015	
Water Quality Objective for Selenium for SF Bay and Delta	USEPA	June 2016	
Statewide Selenium Criteria	USEPA	2019	
Flows			
Bay Delta Water Quality Control Plan Phase I Flow Objectives San Joaquin River Inflows Phase II Flow Objectives Sacramento Inflows Phase II Flow Objectives Sacramento Outflow	SWRCB	 Fall 2016 April 2018 April 2018	
CA Water Fix: Permit for new diversion point will have monitoring requirements. (*Delta RMP angle is monitoring to tease out flow effects on nutrients.)*	SWRCB	Hearings in 2016 Decision in late 2017	Advanced nutrient trend analysis with flow as a covariate
Other Policies/Drivers			
Clean Water Act 303(d) list of Impaired Waterbodies and 305(b) Integrated Report	CVRWQCB	Ongoing (Hearing in Dec 2016)	
CV-SALTS	CVRWQCB	Salt and Nitrate Mgmt Plan 2016 Basin Plan Amendment 2018	
Lower San Joaquin River Salinity Objectives	CVRWQCB	February 2017	
Sediment Quality Objectives: targets for fish tissue for chlordane, DDT, PCBs based on sediment concentrations	SWRCB	July 2017	
California EcoRestore	CA NRA	Implementation by 2020	

Delta RMP Multi-Year Planning Budgets

costs shown in thousands

Where we have been… Where do we want to go… (SC to fill in)

Studies Completed or Proposed	Approx. Cost/Yr		FY14/15	FY15/16	FY16/17	FY17/18	FY18/19	FY19/20	Notes
	Low end	High end	*actual*	*actual*	*actual*	*planned*	*planned*	*planned*	
Pesticides									
Water Sampling at "integrator" sites ("low" design)	??	550	11	513	516				
Adding Water Sampling at "targeted" sites ("medium" desig	74	155							
Technical Report: Analysis of FY15/16-FY16/17 data	50	80				*60*			Note 1
Nutrients (options identified at 9/30/16 workshop)									
Coordination workshops	15	50							
Coordination and Integration Tools	30	250							
Adding nutrient analyses to routine monitoring	10	150							
HAB sampling	100	200							
Nutrient Data Analysis and Reporting	50	500	70	50	120				
Data Synthesis for Specific Area or Habitat Type	50	100							
Adding model parameters to routine monitoring	15	60							
High-frequency mapping studies	100	170							
Mercury									
Water sampling	48	147			48	*66*	*66*	*33*	Note 2
Fish sampling	65	87			65	*60*	*60*	*60*	
Sediment sampling	50	150				*66*	*66*	*33*	
Coordination and Data Mgmt						*30*	*30*	*34*	
Technical Report: Analysis of data through 2019	50	80						*50*	Note 3
Pathogens									
LT2 Pathogens Study	82	82	72	92			*project end*		
Technical Report: Analysis of LT2 data				20		*in-kind*	*project end*		Note 1
Contaminants of Emerging Concern (potential new focus area)									Note 4
Implementing Statewide Pilot Study Design (3 years)	150	175							
Expansion of Pilot Study to fill gaps	20	50							
CEC Strategy Development	25	75							
Technical Report: Analysis of 3 years of data	50	80							

Delta RMP Multi-Year Planning Budgets

costs shown in thousands

Where we have been… Where do we want to go… (SC to fill in)

Studies Completed or Proposed	Approx. Cost/Yr		FY14/15	FY15/16	FY16/17	FY17/18	FY18/19	FY19/20	Notes
	Low end	High end	*actual*	*actual*	*actual*	*planned*	*planned*	*planned*	
Communications									
Foundational Documents				20					
Workshops on Topics of Interest	15	50			20				
Pulse of the Delta (Fall 2018)	100	150				*60*	*60*		Note 1
Other Study Ideas Not Listed Above									
Core Functions									
Core functions, governance, quality assurance	250	350	57	218	275	278			Note 5
Cost as a percent of total budget			27%	24%	26%	65%			
Total	**1,149**	**3,391**	**210**	**913**	**1,044**	**428**	**90**	**84**	Note 6

Total Revenue	**303**	**1,054**	**1,056**	**1,056**	
Reserve Available				**116**	

Notes:

1. Technical report scheduled in Communications Plan. Pulse Report scheduled for fall 2018 release. Cost of Pulse split across two years.
2. Mercury study costs in red would be funded by Prop 1 grant if awarded. Costs in blue would be required RMP match for the Prop 1 grant. Sediment sampling was part of the Prop 1 proposal but is not included in the Monitoring Design.
3. Technical report for mercury is scheduled for FY18/19 in the Communications Plan but moved to FY19/20 for the Prop 1 grant.
4. The Delta RMP is a possible venue for the State Board CEC Pilot Study in the Central Valley. Still to be confirmed. Costs are estimates and based on State Board guidance. Expansion of the Pilot Study means filling gaps in the design (e.g., measuring all PFCs, not just PFOS).
5. Core functions costs for FY17/18 were assumed to be 26% of FY17/18 revenue. The core functions budget will be refined for the workplan.
6. Hg costs covered by Prop 1 funds are not included in total. CEC studies are not included in total because separate funding is expected.

Materials for Agenda Item 6

Independent Panel Review of the Delta Regional Monitoring Program (Delta RMP) Monitoring Design

Phase I: Initial Review

A report to the

Delta Science Program

Prepared by

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Septebmer 2016

Delta Stewardship Council
Delta Science Program

Table of Contents

I. Executive Summary 1
Overall Comments 1
Panel Recommendations 2
II. Features of an effective monitoring program 3
III. Effectiveness of the current monitoring plan. 4
Combining data over time and space 4
Mercury 5
Pesticides and Toxicity 6
Nutrients 8
Pathogens 8
IV. Other Comments 9
List of Acronyms 10
References 11
APPENDIX 1 12
Overview 12
Extended Discussion 15

Independent Panel Review of Delta Regional Monitoring Program (Delta RMP) Monitoring Design

Phase I: Initial Review

I. Executive Summary

Overall Comments

The full charge to the Panel is at the end of this report. In brief, it asks us:

A) Is the Monitoring Design adequate to answer the management and assessment questions?
B) To recommend scientific criteria for distributing limited resources towards monitoring.

A short answer to A) is "Probably not." A major reason is that B) has been largely ignored.

The main tasks of a monitoring plan are to define the quantities and summaries needed to address the management and assessment questions, and to specify a sampling scheme that will lead to estimates of these summaries that are reliable enough to be useful. If the ideal plan would cost too much, it would be scaled back based on priorities of concerns and feasibility of useful results.

The Monitoring Design Summary (MDS**)** is silent on most of these tasks. It defines some quantities without saying how they should be summarized and used for management, and specifies a sampling scheme without saying how it can be used to estimate useful summaries. Costs are mentioned but priorities and feasibility are not. The Quality Assurance Program Plan (QAPP**)** addresses reliability in detail, but mainly to describe control of sampling error for estimates at a single site and time, not the errors for summaries over time or space. The core management and assessment questions are in Table 1of the MDS (pp. 3-7). Many refer to "beneficial uses" which are discussed in the QAPP (pp. 15-24). All of them require judgments about quantities which vary over time and space, as well as due to sampling error.

A sample can estimate the level of an indicator (e.g., contaminant) at a particular point in the Delta at a particular moment in time. This estimate is useful for management or assessment only if it can be used to tell us about levels at other points and times that were not observed.

In some cases, the fact that the level varies continuously may be enough. A high pathogen level found at a recreational site or drinking water intake might trigger management action by itself, because levels nearby in time and space are likely to be high too. More often, however, a summary is needed, such as a trend over time at an important site, an average summer level over a sub-region, or a time trend in such averages.

The Panel cannot be certain that the Monitoring Design is inadequate. It is possible that appropriate summaries could be defined, and that models and methods could be developed by which they could be estimated reliably from this sampling design. Some of this work may have been done in the discussions that led to the design. However, none of this supporting information appears in the MDS.

As it stands, the design will lead to a large collection of data, measuring contaminant levels at a discrete set of sites and times which constitute a vanishingly small part of the Delta and the time period of interest. These data will be of little use unless they can be combined and interpreted to form a description of contaminants over larger areas or periods, or of processes that management action might affect. The "Example Data Products" are graphs that display data over space, time or both, but do not extract major messages, uncertainties, or implications for action. The MDS (p. 16) says "Interpretation and reporting methods will be described in a Communications Plan" but they are not.

Panel Recommendations

A list of main recommendations follows. Others more specific to separate studies are in Section III.

1. **We recommend that the monitoring team include one or more environmental statisticians, employed full-time, to refine the sampling design and develop the methods for data analysis.**

2. Monitoring and assessment of the state of the Delta is based on a sample of the study area—that is, not all possible locations are sampled and indicator values measured. Therefore, the ability to use the sample data to draw inferences about unmonitored sites is a key part of sample site selection. This has several components. One is to use models of flow, transport and degradation to help estimate values up- or down-stream of monitored sites. The five pesticide sampling sites may allow crucial areas to be estimated this way (but they are likely to be small and no methods are given). Another approach is statistical. The standard approach has a large literature based on mathematics, simulation and experience. It selects sites partly randomly, using an objective procedure like computer-generated random numbers. (Haphazard, intuitive, or convenience sampling are not substitutes.) While easy in principle, this approach can be hard in practice. Stratification is often needed to ensure that sites in different subareas or of different types are adequately represented. The number of sites may need to be increased by reducing the frequency of sampling or other changes (see Section III). Methods may need to allow for some selected sites turning out to be inaccessible. Some details are in Section II and the Appendix. One motive for the first recommendation is that some of these details require familiarity with statistical methods.

3. Tidal phase and variation in flow need to be taken into account in the sampling plans**.** This may not be relevant for all constituents (such as pathogens at the water intakes or mercury testing in fish), but it is likely to be important for some. The presentation to our review team on August 23, 2016 included a figure from the USGS showing how sparse sampling on a tidally oscillating time series could lead to erroneous conclusions. For example, some variables such as pesticides and nutrients are likely to be associated with local point source introductions to the Delta. If two samples are made at a location near a significant point source but the tidal currents are in opposite directions, one sample could measure the pesticide and the other would not. If these 2 samples are months apart, no significant seasonal difference can be inferred because the difference may be due to tidal flow direction instead. If tidal phase is not considered in the sampling plan, there is no way to isolate the effect. Several recommendations for taking tidal phase into account are included in the detailed discussion of specific constituents (see Mercury and Nutrients under section III).

4. A useful beginning would be **to restate Table 1 of MDS to more specifically address the management questions, monitoring goals, and likelihood of achieving these goals for each constituent.** In some cases, numerical goals (albeit approximate) may be needed for areas (rather than single sites) or periods (rather than single times). How well do the "lower", "midrange" and "higher" sampling levels achieve the monitoring goals? How were the prioritization decisions (shown by stars in Table 4) made? Careful assessment should help ensure that resources are allocated efficiently, are directed towards achievable goals, without being spread too thin. In some cases, the sampling may not be worth doing, because it is not tied to management goals or is too sparse to be useful. For example, the medium cost level for pesticides is over half of the total for the entire recommended program; the higher level is 2.5 times larger, with nothing in between. Yet we don't know that there is a problem or signs of a problem (the initial question). Less costly sampling might tell us. Until then, some of these resources might be better spent on other constituents.

II. Features of an effective monitoring program.

The principle goals of environmental monitoring programs are to inform the management decision making process. Effective programs:

- provide reliable descriptions (usually quantitative estimates) of the state of the resources being managed and of changes over space or time
- use these descriptions to assess the need for possible management actions
- evaluate the implementation and effectiveness of management actions
- update our understanding of how the system operates.

Successful environmental monitoring programs have several characteristics in common. These include:

In the design document, the monitoring program identifies state variables (e.g., indicators) to be measured at sample locations but does not fully explain why these indicators were selected. For example, lab analyses do not assess "pesticides" or "nutrients": they assess particular pesticides and nutrients. Each one added can increase costs, each one ignored can increase risks, and there may be legal requirements. What logic was invoked to justify the selection of the indicators to be measured?

The monitoring objectives are clearly defined quantities that can be observed or estimated from objective measurements. Initial management questions in the documents were usually in words, not numbers: "is there a problem?", "what is the status?", or "is toxicity too high?" These need to be restated in measurable terms, usually as means or trends over time or space (including subregions or tributaries, etc.) or both. Even when a numerical quantity is given, as for some water quality objectives, it may refer to a single observation or to an average over a sample size, area or time period which has not been specified.

The spatial and temporal domain of the population of interest is defined. The spatial domain will usually require a map. Ideally, the sampling scheme should allow the value of any quantity of interest at any place or time in the domain to be estimated, as well as patterns such as means or trends over space or time. It should usually take into account influences originating outside the domain (especially the spatial domain) which contribute to the values inside it.

The desired reliability for important estimates is specified. The "important" estimates are those in the monitoring objectives whose values are key to answering management or assessment questions, and have a clear potential to trigger management actions. (Other estimates might be made in passing because they are cost-free, but need not be in the plan details.) The measure of "reliability" needs to be defined, not only for estimates at a given place and time but for expanded inference in time and space.

The desired reliability for important estimates is justified in detail. We separate this from the previous point because carrying it out requires other steps. The justification can take several forms:

- Some actions may be legally required if a threshold is crossed.
- Other thresholds and actions might be recommended by the monitoring team.
- Some cases might involve several possible management actions, each with a set of possible outcomes whose probabilities can be calculated conditionally on the estimates.

Each of these forms involves an analytical protocol, such as a statistical test or a formal decision analysis, whose effectiveness depends on the reliability of the estimates. Thus the justifications require:

- explaining how each important estimate can lead to management actions, either on its own or as part of a more general assessment of the Delta or a subregion of it;
- describing the protocols that might be used to decide the action;

- explaining why the specified reliability is adequate for these protocols.

The sampling plan is shown to be likely to achieve the desired reliability. The protocols do not pre-empt the role of management, which weighs economic and other concerns as well as protocol results. However, unreliable protocol results may not be worth their cost. Here is an artificial example:

Suppose we test a town's drinking water by giving it to mice and then examining them for cancer. If lab costs limit us to 20 mice, we might issue an alarm if any have cancer. Some mice get cancer anyway: suppose this background rate is 2%. If the town water is in fact safe, the 2% risk gives a 33% chance of getting at least one case and issuing a false alarm. Even if the water doubles the risk of cancer to 4%, the chance of a "true" alarm is only 56%. We can reduce the false alarm rate to 6% by requiring two or more cancers, but then the true alarm rate drops to 19%, so we miss 81% of cases we want to detect. For all its seeming importance, this test is probably too unreliable to use at all.

Determining reliability from a given spatio-temporal sampling plan, or designing a plan to achieve sufficient reliability for a given cost, are not easy tasks. We discuss them in Appendix I not to solve the problem for the Delta program, but to show that solving it requires effort and expertise similar to those needed to choose the most important contaminants and find ways to measure them.

The program allows for ongoing estimates of uncertainty and updates to the sample design as needed. All components of the monitoring program are accompanied by uncertainty. However, as data are collected over time, these uncertainties can be narrowed if the monitoring data are used to update your understanding of how the system works. In some cases, the data might lead to a redirection of effort. For example, the current plan samples mercury in water only because it may suggest ways to control methyl mercury in fish. If, after a reasonable time, the two measures seem to be unrelated, indicating that mercury does not predict methyl mercury even allowing for time lags or flow between sites, it might make sense to drop the mercury sampling and extend the fish sampling.

III. Effectiveness of the current monitoring plan.

This section contains comments from Panel members.

Combining data over time and space

The main weakness of the current plan is given in the Summary: it has little connection to management action or assessment because it does not combine data from different sites and times to form a description of the current state of the Delta, its changes over time, or the processes involved.

The QAPP (p. 12) says the program arose from "shortcomings of existing monitoring efforts to address questions at the scale of the Delta [and] recognition that data from current monitoring programs were inadequate in coverage, could not easily be combined, and were not adequate to support a rigorous analysis of the role of contaminants …" However, there are several statements like the following:

- Communications Plan, p. 9: "The exact methods for data analysis are not prescribed in this plan because doing so would limit the options for the program."
- QAPP (p. 15): "decisions … will be made by the Water Board using its own process. Therefore, the Delta RMP does not have a detailed assessment framework for data interpretation and follow-up."
- Fact Sheet: Ambient Toxicity (p. 3): "Available information allows conclusions about monitored areas and sites but cannot be used to make assumptions about unmonitored areas."
- QAPP (p. 64): "Individual results produced by the Delta RMP are not intended to trigger enforcement actions, even though collectively the data may guide management actions …"

The first statement is misinformed. Statistical methods can change when the data suggest that some assumptions are wrong, but not often and usually only in details such as the covariates to use in prediction or the shape of a probability distribution. The second is an understatement: there is almost no framework at all. The third is confusing: since only sites are monitored, a "monitored area" is an area containing monitored sites, which can be used to "make assumptions" (inferences) about it; it is unclear what an "unmonitored area" is. The fourth seems to regard linking data to action as someone else's job.

This stance contradicts the idea of a monitoring design. Why sample monthly if bi-monthly or annual samples would be nearly as good, and allow more sites? Why are sites for monthly pesticide samples all near the edge of the Delta if these are not informative about interior sites? (Pages 24 and 38 of the MDS lists reasons for site choices but they are vague.) How would one decide whether the proposed design is better than one with half as many times and twice as many sites? The QAPP aims to ensure that results from individual (site, time) samples meet reliability criteria: how are these determined? How would one decide whether to relax some of them so as to add more sites or times, or tighten others due to health risks?

Mercury

Use of Sportfish as a monitoring parameter

What is the goal of the mercury program? If it is to set human fish consumption advisories, then are the sampling locations chosen where people actually fish? Using large sportfish to monitor potential human health impacts from eating those fish makes sense.

However, using sportfish to monitor impacts on MeHg from large restoration projects does not make sense. Large sportfish have fairly large territories/home ranges, so it would be hard to attribute change to a specific restoration action or location. Also, the change would be hard to detect, since large sportfish have higher Hg body burdens that vary more between individual fish. As a result, a small change from a management or restoration action won't stand out. Small, resident fish with small home ranges would reflect such changes more quickly and clearly. Ideally a Before-After-Control-Intervention design could be used.

Sampling schedule

The sportfish are sampled annually. Do we know if mercury varies seasonally in sportfish, as it does in smaller fish? If so, then annual samples are unlikely be adequate unless people catch and consume the fish in only one season, or there is a way to adjust for other seasons (without sampling at those times). If mercury in sportfish varies spatially within a subregion, then sampling one location per subregion is unlikely be adequate. This could be a case where the goal is useful but the effort is far short of what is needed, and thus achieves nothing. How will the data be analyzed to compare trends among sites?

The mercury water samples are monthly. What connects them to the fish tissue samples? Are they at the same sites (including Mokelumne River)? Are they to be compared to the water quality (WQ) criterion of 0.06 ng/L of MeHg in unfiltered water (QAPP, p. 24, Table 3.4)? What will a monthly grab sample at 4 sites in the Delta tell you about MeHg status in the entire Delta? How were the number and locations to be sampled determined? What are the flows at these locations? Will all samples be taken under the same tide/flow conditions?

Additional questions and comments from the panel

- Why is there a low level of fish sampling and a medium level of water sampling? What is the value of the water sampling? How does current fish sampling data relate to previously collected

sampling data? If the primary management question is trends over time, are there existing long term data sets that can be built on. The study plan mentions but does not elaborate on these points (MDS, p. 38).

- How were the bin lengths for the Largemouth Bass determined (QAPP p. 86)? The Central Valley Basin Plan has water quality objectives (WQO) for fish 150-500 mm TL, and for fish <50mm TL, so the proposal's sampling divisions (200-249, 250-304, 305-407 and > 407 mm) are not consistent with this Plan. Fish Hg will often vary by length of fish (surrogate for age). How will the data be compared to WQO? Will bins be analyzed separately? The sampled fish can be assumed random within bins, but not between them; is the plan to fit a regression of fish Hg against length? Note the Basin Plan is specific as to trophic level of fish for the WQO: any alternative predator species should be at the same trophic level.

- Some plan details seem missing or contradictory:
    - Little Potato Slough is not shown on Figure, MDS p. 38.
    - MDS p. 9 says "10 sites" and "350 mm length". QAPP p. 34 shows 6 sites. p. 86, Table 8.3, says 11 fish per site to get 66 individuals, in 4 size bins (200 mm to 500 mm length), so 6 sites.
    - MDS p. 9 says water samples are monthly. QAPP p. 25 says they will be "analyzed" quarterly.
    - QAPP p. 24. Table 3.4. What is the time period for these benchmarks? Are they average concentration? Does the information here agree with Appendix 43 of Central Valley Water Board? Where is the "0.06" level of MeHg in the WQCP? (Is it an average? If so, over what?)
    - MDS p. 39. How will these ancillary parameters be used in analyzing or interpreting the MeHg in water data? Are data relevant to these parameters already being collected by others? e.g., suspended sediment. What are the "conditions" in the footnote?
    - MDS pp. 38, 41. The figure shows 10 fish collection locations, but the table lists 9. <u>It would be helpful to show sampling location numbers in both the figure and the table</u>. Some names in the figure do not match those in table - e.g., "S. Fork of the Mokolumne@ Staten Island" and "Mokelumne River at Benson's Ferry" are in the figure, not in the table, or have different names. It would also be helpful to show the demarcation of the TMDL subareas, since that is the primary rationale for selecting sites.

<u>Pesticides and Toxicity</u>

This is by far the most expensive program and has the potential to become much more so if new or unknown pesticides become an issue. Yet, at present, we do not know the answer to the basic Table 1 question: “What are the spatial and temporal extents of lethal and sub-lethal toxicity?” In fact, we were told at the presentation meeting that so far there has been no observed toxicity, but there was information (not specified) that pesticides may be contributing to toxicity in the Delta.

More detail on toxicity tests is needed. It seems more cost-effective to document the toxicity problem first, by postponing pesticide analyses to pay for toxicity testing over more sites, more widely spread, and during times of year when pesticide use/runoff would be expected to be high. When the sites or areas experiencing toxicity, and the times of the year are known, then samples from these sites and times can be analyzed for the chemicals that might cause that toxicity. This information can then be used to determine source(s), which can then lead to control/management.

Toxicity design

The vague categories used (non-toxic, some, moderate and high: MDS p. 26, 27) are not useful. At present it is proposed to conduct "Pesticide-focused TIEs for samples with > 50% reduction in the organism response compared to the lab control treatment (not to exceed 20% of samples or $40,000)" (MDS p. 21). What criteria led to these numbers? The toxicity tests use "EPA, 2002, Appendix H" (QAPP, p. 61, it should be "2002a"). It is an old t-test (its formal pre-tests are not useful). How the test is to be used (what action it might lead to), and how reliable it should be (a function of sample sizes and variances) are not clearly discussed. (The aims and meaning of the measurement quality objectives column in Table 4.10 is not clear.)

Pesticide sampling design

What samples sizes will be used, and why? In the 2-stage approach above, a decision procedure will be needed to decide which sites and times are candidates for pesticide analysis, and perhaps to choose the pesticides to look for. Thresholds, trigger points, and estimates of reliability will be needed, especially if information from different sites or times is to be combined.

When samples are collected from locations with observed toxicity and analyzed for chemicals, will current use pesticides be the only targets? Is there reason also to consider personal care products, PBDEs (flame retardants), pharmaceuticals, legacy pesticides in sediment (e.g., DDT) or Hg as causes or contributors to observed toxicity?

If protection of human health is a major goal, then sampling is needed in those areas expected to be used as a drinking water sources (e.g., at specific drinking water intake locations). Sampling for pesticides in water not near drinking water intakes (or perhaps recreation areas) does not seem to provide useful information to address this goal.

Sediment sampling design

The plan is not clear about methods for sampling sediments. The QAPP has no information on sediment collection or analysis. Is the Stream Pollutions Trends Monitoring Program (SPoT) collection, toxicity testing and chemistry of sediments considered part of the Delta RMP? Where are those sample locations? A yearly grab sample seems very limited - what is known about the spatial distribution of pesticides in sediment, or their seasonal variation? There are no standards, criteria, or objectives for the prevalence of current use pesticides in sediment, so what would be done with this information? What will the estimated concentrations be compared to in order to evaluate the presence and degree of sediment toxicity? The map on p, 26 of MDS shows there are existing sediment and/or water toxicity test locations in the Delta that have known toxicity (at least within the vague categories). Can these locations be used as negative and positive controls, respectively?

Additional questions and comments from the panel

- Some water samples are scheduled and others triggered by events. If these are to be combined over time, how will they be analyzed? Presumably "event" times have special characteristics, and wet ones are different from dry ones. (This is a question, not a criticism of taking the two types of samples.)
- It seems that monthly samples are not taken when "events" occur. In that case, why are the "event" sites different from the regular sites?
- MDS Table 2, p. 12, does not show toxicity testing.
- QAPP p. 11. There are 3 different entities analyzing water -- does each entity collect its own samples? Can sample collection be consolidated?
- QAPP p. 30. Are the same sites used for both pesticide analyses and toxicity testing?

Nutrients

Monitoring design

One of the initial driving questions (p. 44) is "are there important data gaps associated with particular water bodies within the Delta subregions." It seems appropriate to answer this question before designing the sampling plan and locations for the Delta RMP.

How are tides, flows, and other hydrodynamic conditions considered in choosing where and when to sample?

The MDS (pp. 47-52) shows several ways to display the data, including its variation over time and space. Displays like these are informative, and might help in developing the nutrient monitoring design, or redirect or focus future sampling. However, displays are not a sufficient end point. They do not provide clear criteria for management actions. Such criteria usually need to be numerical estimates, with estimates of reliability. They will arise from comparisons to water quality objectives or other benchmarks of environmental or human health.

We recommend that a PhD-level statistician be added to your team to help develop the nutrient monitoring design.

Synthesis

An allocation of $435,000 seems high for mostly synthesizing the existing data (MDS, pp. 45-52).

Pathogens

Sampling design and data interpretation

It seems too late to make changes in this program. Our concerns over using the data to make inferences about unsampled sites are less here, because many of the sampling sites are important in themselves.

However, it is still unclear what inferences can be drawn about ambient levels elsewhere, which are listed as a goal. How are the sites called "general characterization" (MDS, p. 61) to be used? The Fact Sheet for Pathogens (p. 6-7) says monitoring for ambient levels and sources " should entail representative discharge /effluent locations such as wetlands, urban runoff, POTWs, agricultural/farmland animal areas." It is not apparent that the locations selected for the study are near such areas (see Figure, MDS, p. 62).

Additional questions and comments from the panel

- MDS, p. 14. Pathogens - Cyrptosporidium and Giardia only have narrative WQO - "Waters shall not contain C and G in concentrations that adversely affect ...MUN beneficial uses." What is that level? How do we know what a reasonable detection limit needs to be?
- MDS, p. 60. This involves "triggers". What are they and how are they determined?
- MDS, p. 61. Fate and transport should include a consideration of hydrodynamics. How will sources be identified with this study design?
- QAPP, p. 31.
    - Another program is also collecting pathogens at different sites? Are the analytical methods, quantification limits, etc. similar between the lab that MWQI uses and that which RMP uses?
    - "MWQI … at each of the locations shown in Table A-1…" There is no Table A-1.

QAPP, p. 112. Table 3.5 lists values for Cryptosporidium only - are those values what the monthly sampling will be compared against? What will the Giardia sample results be compared against?

IV. Other Comments

Earlier programs
In what specific ways were former/current monitoring programs "not adequate"? (QAPP, p. 12). Was there a report that evaluated the programs and identified specific deficiencies and made recommendations for improvement? If so, it would be helpful to address how this plan makes up for prior monitoring program deficiencies.

Water Quality Objectives.
What are the time frame definition for "acute" and "chronic" in the WQO or WQC (QAPP, p. 17)? Many of the samples in the Specific Monitoring Designs are monthly grab samples, so it is not clear that the sampling timeframes are consistent with the evaluation criteria. If they are not, then how is Delta RMP to be used for its primary objective, to assess whether Beneficial Uses are being impaired?

Maps and tables.
Sampling location numbers should be given in all maps and tables. Much time can be wasted trying to link them.

Lab measurements (QAPP p. 48.)
Is the plan to compare concentrations in water to water quality objectives/criteria or other benchmarks? Are these reporting limits and method detection limits sufficiently below the benchmarks that there is confidence in the quantification of the concentration?

What are the detection limits/limits of quantification for the analyses (QAPP p. 93)? These limits can be lab specific. It is not clear from the information provided in QAPP, whether the stated analytical methods are able to accurately detect concentrations at or near the WQO or WQC.

Adaptive design.
QAPP (p. 78) says "Collected data are used to evaluate future data needs and adjust the sampling and analysis plan as needed to optimize data collection in an adaptive manner. The program will be continually adjusted to optimize data collection." There seems to be nothing on how this is to be done.

Graphs.
Pie charts should not be used: a table or bar graph is always better. Fake dimensions should not be used. The main value of plots is to convey much information clearly and succinctly, but thought and explanatory text are often needed; **MDS**, p. 28, contains much information but is uninterpretable (other than high scores for Diuron). Plots on p. 52 are better, but still need summarization of both the messages and their reliability.

List of Acronyms

ASC: Aquatic Science Center (aka SFEI-ASC)
AHPL: Aquatic Health Program Aquatic Toxicology Lab
CCWD: Contra Costa Water District
CEDEN: California Environmental Data Exchange Network
CEQA: California Environmental Quality Act
CMP: Coordinated Monitoring Program
CRMP Certified Reference Materials
CVDWPWG: Central Valley Drinking Water Policy Workgroup
CVWQCB: Central Valley Water Quality Control Board
Delta RMP/DRMP: Delta Regional Monitoring Program
DPR: Department of Pesticide Regulation
DTMC: Delta Tributary Mercury Council
DWR: (California) Department of Water Resources
DO: Dissolved oxygen
DOC: Dissolved organic carbon
DON: Dissolved organic nitrogen
DSM2: Delta Simulation Model II
DSP: Delta Science Program
EC: Electrical conductivity
ELAP: Environmental Laboratory Accreditation Program
EMP: Environmental Monitoring Program
ESWTR: Enhanced Surface Water Treatment Rule
FWS: US Fish and Wildlife Service
FY: Fiscal Year
Hg: Mercury
IEP: Interagency Ecological Program
IEP-EMP: Interagency Ecological Program Environmental Monitoring Program
ILRP: Irrigated Lands Regulatory Program (part of Central Valley Regional Water Quality Control Board)
LT2: EPA's Long Term Enhanced Surface Water Treatment Rule outlining monitoring requirements for Cryptosporidium.
LRM: Lab Reference Material
MeHg: Methylmercury
MDL: Method Detection Limits
MLML: Moss Landing Marine Laboratory
MPSL: Marine Pollution Studies Lab at Moss Landing Marine Lab
MQO: Measurement Quality Objectives
MS: Matrix Spikes
MSD: Matrix Spike Duplicate
MST: Microbial source tracking
MWQI: Municipal Water Quality Investigations (a Department of Water Resources program)
NELAP: National Environmental Laboratory Accreditation Program
NPDES: National Pollutant Discharge Elimination Systems (US EPA permit program)
NWQL: National Water Quality Laboratory
OCRL: Organic Carbon Research Laboratory
PCR: Polymerase chain reaction
POC: Particulate organic carbon
POD: Pelagic Organism Decline
POTW: Publically Owned Treatment Works (sewage treatment facilities)
QA: Quality Assurance

QAO: Quality Assurance Officer
QAPP: Quality Assurance Program Plan
QC: Quality Control
RL: Reporting Limit
RMP: Regional Monitoring Program
RPD: Relative Percent Difference
RWQCB: Regional Water Quality Control Board
SC: Steering Committee (of the Delta RMP)
SDWA: South Delta Water Agency
SFEI: San Francisco Estuary Institute (now SFEI-ASC)
SFRWQCB: San Francisco Regional Water Quality Control Board
SPoT: Stream Pollution Trends monitoring (a program of the California Department of Water Resource's Surface Water Ambient Monitoring Program)
SRWTP: South Delta Water Agency
SWAMP: Surface Water Ambient Monitoring Program (a California Department of Water Resource's division)
TAC: Technical Advisory Committee (of the Delta RMP)
TDN: Total Dissolved Nitrogen
TIE: Toxicity Identification Evaluation
TL3: Trophic Level 3
TMDL: Total Maximum Daily Load
TN: Total Nitrogen
TSS: Total Suspended Solids
TST: Test of Significant Toxicity
UCD: University of California, Davis
USEPA: US Environmental Protection Agency
USGS: US Geological Survey
UVA: Ultra-violet absorbance
WDR: Waste Discharge Requirements
WPCL: Water Pollution Control Lab
WTP: Waste Treatment Plant

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APPENDIX 1

This section discusses sampling plans intended to describe an area over time. While some sites might be chosen for their importance (e.g., drinking water intakes), their information may apply only to small neighborhoods. The plans we discuss here aim to provide reliable estimates for the entire area, at single points in time and over periods.

Overview

In the following we briefly outline some basic principles of successful and defensible environmental monitoring programs. To our knowledge, the single best source that discusses these principles in detail is a 2012 book entitled: "Design and Analysis of Long-term Ecological Monitoring Studies", edited by R.A. Gitzen, J.J. Millspaugh, A.B. Cooper, and D.S. Licht. In chapter one of that book, the editors state that "… inadequate attention to qualitative and quantitative design issues has been reported to be a common problem in environmental monitoring programs…" We agree with this statement and believe it characterizes several key weaknesses in the Delta Regional Monitoring Program, particularly the lack of quantitative design and analysis details in the RMP monitoring design document. The reality is that development of effective sampling design and analytical methods for monitoring programs involves complex quantitative issues that require extensive engagement by an environmental statistician.

General Principles

Monitoring programs must be efficiently administered, adequately funded, supported by the clients of the monitoring program, have effective data management procedures and regular reporting schedules. However, our focus here is on the essential analytical components for environmental monitoring. Fortunately, there is a strong consensus in the scientific literature on the essential components of monitoring programs designed to assess status and trend. The key requirements are to:

1) Specify objectives in terms of measurable attributes
2) Identify the monitoring state variables (e.g., indicators) and why they were selected
3) State the spatial and temporal domain of the population of interest (i.e., the sample frame)
4) State the type of change to detect
5) Specify the magnitude of change to detect (effect size; essential for sample design decisions)
6) Following (5), specify desired precision for the trend estimate (requires pilot data and a components of variance analysis)
7) Generate estimates of uncertainty
8) Specify 'trigger point' (thresholds) that will lead to a management response
9) Specify the management action that will occur
10) Determine (monitor) the effects of the management actions
11) Update design as needed (adaptive monitoring)

All of the above steps are important but program components cannot compensate for inadequate attention to design and analytical issues. Specifically, we believe that the statistical model(s) to be used for analysis must be decided upon early in the process. Given specific monitoring state variables (indicators), sampling objectives such as desired statistical power, effect sizes, and statistical precision require a priori identification of specific statistical methods. Failure to do this makes it impossible to perform basic sample size calculations and to optimally allocate sampling effort across time and space. This also ensures that limited project funding is used in the most efficient way and is not wasted. Decisions on sample designs, methods of analysis, and variance components analysis go hand-in-hand and should occur before major data collection begins.

To clarify the components of variance concept, we assume a design in which each site is visited in each of a set of years. Given this assumption, the key components of variation are (see expanded discussion by Scott Urquhart in chapter 7 in Gitzen et al. 2012):

1) Spatial: variation among sample units (sites); treated as a random effect in an ANOVA model
2) Temporal: how much the state variable varies from year-to-year across all sample units; treated as a random effect
3) Space by time interaction: how much the state variable changes across time within a sample unit independent of changes in other sample units
4) Error variance

Partitioning the total variance is expressed as: $\sigma^2_{Total} = \sigma^2_{site} + \sigma^2_{time} + \sigma^2_{site\ x\ time} + \sigma^2_{error}$

To estimate trend, we must first assume a model for how the response variable (e.g., indicator value at sample unit i) changes over time. For example, if we assume a simple linear time-trend model for the indicator, y, our model is:

$$y_{ij} = \mu + S_i + T_j + \varepsilon_{ij}$$

where,

$y_{ij} =$ the value of the state variable at site i in year j

S_i = effect of site i

T_j = effect of year j; {j = 1, 2, … , t}

$\varepsilon_{ij} =$ error term

Then our estimation model for a linear trend, assuming a common trend across sample sites, is:

$$\hat{y}_{ij} = \beta_0 + \beta_{1j} + \varepsilon_{ij}$$

where,

β_1 estimates trend

$\beta_0 + \beta_1(t+1)/2$ estimates 'status'

The null and alternative hypotheses of interest are, respectively: H_0: $E[\beta_1] = 0$; H_a: $E[\beta_1] \neq 0$. That is, to detect trend we test the null hypothesis that no trend is present in the indicator against the alternative hypothesis that a trend is present. The ability of a monitoring program to detect trend when it is truly present is referred to as its statistical power.

The best source of information for a component of variance analysis is from preliminary survey data. These preliminary data also provide information essential for sample-size calculations and determination of an optimal sampling design.

Design-based or Model-based

There are two broad categories of environmental monitoring programs—design-based and model-based. Both require that the target population and the sample frame be clearly defined in order to avoid the potential for confounding arising from changing frame errors. Those programs that use design-based inference use the selection probabilities of the sample units to calculate an estimate for the statistical population and provide estimates of uncertainty. In contrast, programs that use model-based inference assume an a priori statistical model for the distribution of indicator values and do not require a probability based sample design. The following discussion develops this distinction further.

At each sample site i there is an observable value Z_i for the indicator attribute. In a designed-based view, Z_i is a fixed quantity. Any probabilistic process that may have produced Z_i is unknown and irrelevant. The probabilistic component of the data arises from the sample design itself (i.e., a simple random sample with equal probability of inclusion for each sample unit).

In contrast, in a model-based view, Z_i is a random variable—a random realization from a statistical model, such as a normal, with mean μ and variance σ^2. The values $Z_1, Z_2, \ldots, Z_N$ at any time t are just one outcome of many possible outcomes under the statistical model. Under this model, the sample design that provides the data is irrelevant.

In the design-based view, if the goal is to estimate the population mean, then we simply compute:

$$\hat{\bar{Z}} = \frac{1}{n}\sum_{i=1}^{n} Z_i$$

Even if the entire population, N, had been sampled and the mean was based on a census, the estimate provides no insights to μ since we have observed only one realization from the statistical distribution. Generally, n << N, and there is uncertainty about both the realized mean (due to sampling variance) and the parameters of the statistical model that generated the Z's.

In contrast to a design-based approach, if we use a model-based approach and re-compute the mean, as above, from the sample of size n (where the sample design is irrelevant) then the expected value of the sample mean is:

$$E\left[\hat{\bar{Z}}\right] = \mu$$

Designed-based inference makes three assumptions: 1) the values, Z_i, that are measured at each sample unit are fixed quantities; 2) the only source of error in the population estimate is due to sampling variation—that is, no distributional assumptions are made about the data; and 3) all values are measured perfectly.

In contrast to designed-based, model-based inference assumes: 1) there is some statistical process that generated the observed data—the super-population model; 2) we have an approximating model—that is, an a priori hypothesis that we can translate into a well-defined model; 3) our approximating models lies close to truth. In general, analyses for model-based programs are considerably more complex than for design-based programs.

Many environmental attributes, including indicator values in the RMP, are likely generated by dynamic processes. Because of their inherent dynamics, measured indicator values have two sources of uncertainty—uncertainty arising from the sampling process and uncertainty about the underlying statistical processes that generate the observed values. Thus, model-based designs may seem most appropriate because they better characterize the generating process for the indicator values. However, based on our knowledge of environmental monitoring programs, design-based approaches are most common. The primary reason is that there is seldom sufficient knowledge of the system to develop a strong a priori hypothesis about the statistical generating model for the data. The generating process is likely to be extremely complex due to the complexity of natural systems, particularly those disturbed by human drivers. It is usually very difficult to identify all of the un-modeled (and unknown) environmental factors that affect the assumed statistical model for the data.

In practice, many environmental monitoring programs are a hybrid of design-based and model-based components. For example, in wildlife and fishery studies, estimating the abundance, and temporal trend

in abundance, of a harvested species is a common objective (Pollock et al. 2002). In this case, abundance in sample unit *i* is most often assumed to be fixed during the survey period (designed-based) but it is recognized that abundance is estimated with error. As a result, an observation model is adopted to model uncertainty in the measurement process. This model estimates the probability of detection, *p*, conditioned on the animal's presence in the sample unit. Based on the number of animals counted in a sample unit (C_i), the adjusted estimate of abundance is then given by:

$$\hat{N}_i = \frac{C_i}{\hat{p}}$$

Inference to the Target Population

The goal of environmental monitoring programs is to make inference to the status and trend of the entire target population based on a sample of that population. Making inference to indicators values at un-sampled locations is inherently a model-based task. If the program for indicator estimation is model-based to begin with, then extrapolation from the sample data to un-sampled locations is more direct than for designed-based programs.

Because design-based monitoring is grounded in a random sample design where all potential sampling units have a non-zero inclusion probability, inferences can be made to the entire sample frame. However, this extrapolation is not spatially explicit—that is, it does not allow prediction at the scale of un-surveyed sample units. Extrapolation to this scale can be accomplished by measuring one or more covariates at the sample locations. This is followed by estimating a statistical model that relates spatial variation in the indicator values—for example, by means of multiple regression—to the covariates. Prior knowledge, or measurement, of the covariate values at the un-sampled locations allows one to predict (with uncertainty) indicators values throughout the study area.

Extended Discussion

This section is a short account of model-based and design-based sampling plans. It also uses a simple design-based plan to show how the intended data analysis can help guide choices of sites and times.

To outline the problem, suppose we are to monitor a variable, Z, the level of a contaminant, over a region, R, for a time interval, T. At each site s = (x, y) = (Latitude, Longitude) in R, and each time t in T, there will be a value of Z, say Z(s, t). Our goal is to estimate some summary of these values, like the average over both space and time, say $\bar{Z}(\blacksquare, \blacksquare)$. (The "■" indicates we have taken the mean over all values of the missing variable.) We cannot observe Z for all sites and times. We need a set of (s, t) choices, say (s_1, t_1), (s_2, t_2), …, (s_n, t_n), so we can get a good estimate of $\bar{Z}(\blacksquare, \blacksquare)$, say $\hat{Z}$, by applying a formula (which we must devise) to the values $Z(s_1, t_1)$, …, $Z(s_n, t_n)$.

The analysis (inference) step is to measure the reliability of $\hat{Z}$. The most common measure for unbiased estimates is the standard error (SE). This is a hypothetical value obtained by imagining the entire process (the area obtains its Z values, we choose sites and times, get the Z values and apply the formula) being repeated over and over. If sites, times and Z values were the same for each repetition, then all $\hat{Z}$ values would be the same and the measure would be useless. Thus chance must enter into the (s, t) choices or the Z values, or both. (This account assumes that Z(s, t) is observed exactly; otherwise there is observation error which can be estimated from individual samples and is often smaller.)

In a model-based approach, the value of Z at a given site s and time t is treated as a random variable, resulting from natural processes occurring over space and time. These are described by a model, called a superpopulation model, as if the full collection of Z values is randomly chosen from a set of possible

collections. Even for fixed (s, t) choices, imaginary repetitions of the sampling process will give different Z(s, t) values. Each Z(s, t) has a variance and each pair, Z(s, t) and Z(u, w), has a covariance. If these are known, the SE of $\hat{Z}$ can be calculated for any set of (s, t) choices.

However, the conditions where this approach is effective, and the questions it answers best, are different from those of the Delta Regional Monitoring Program. It focuses on modeling the processes represented by the data and predicting what they will do in future. It estimates summaries of the actual Z(s, t) values, such as $\overline{Z}(\blacksquare, \blacksquare)$, only in passing: its real targets are the parameters of the underlying process. For this, it must have a suitable model which is detailed enough to use values at one set of times and sites to help predict values at another set. Usually this requires models of specific physical, chemical or biological processes which operate at many scales but combine to have effects at the larger scale. It also requires large amounts of data to help distinguish between competing models. These questions and conditions apply to the study of climate, but not to the Delta program. Here the questions concern current (actual) status and trends - which are descriptions of (actual) data over time. Concerns about the future are not based on specific causative models but on the belief that the trends are the result of continuing human activity. There are no detailed models for the Delta-wide processes and not enough detailed past data to generate and assess them. We therefore do not discuss model-based designs further.

A "pure" <u>design-based</u> approach is to choose (s, t) pairs randomly, using computer-generated random numbers. The full set of Z(s, t) values is assumed fixed though unknown. When the process is repeated (in imagination) to get the SE, the values of Z are observed at a different set of (s, t) choices. Thus $\hat{Z}$ will vary between repetitions. Its SE depends on the variation of the full set of Z(s, t) values, and the chance comes entirely from the random (s, t) choices.

Usually the selection is more structured. We separately choose random sites and a set of times sufficiently spaced so Z values at different times can be assumed to be independent. If the sites are s(1), s(2), …, s(m) and the times are t(1), t(2), …, t(n), then our observations are the values Z(s(i), t(j)) for each of the mn combinations of an i and a j.

A natural estimate of the average of <u>all</u> Z(s, t) values (giving all sample sites and times equal weight) is the average of <u>observed</u> Z(s(i), t(j)) values:

$$\text{Average of sample values} = \Sigma\Sigma Z(s(i), t(j))/mn.$$

The variance of this average is (after some algebra):

$$\text{Var}\{\Sigma\Sigma Z(s(i), t(j))/mn\} = \sigma_S^2/m + \sigma_T^2/n + \sigma_{Int}^2/mn \qquad ***$$

where,

σ_S^2 = Variance over all sites, s, of $\overline{Z}(s, \blacksquare)$ which is the mean over all times of Z(s, t).

In other words, get the mean over time of each site; then get the variance of these means.

σ_T^2 = Variance over all times, t, of $\overline{Z}(\blacksquare, t)$ which is the mean over all sites of Z(s, t).

σ_{Int}^2 = Variance due to interaction.

One way (of many) to describe σ_{Int}^2 is as "variance due to non-additivity". If the values of Z(s, t) were additive over sites and times, then all sites would change over time in unison. If one site went up by 5 from year 1 to year 2, then they all would. If that were the case, then

$$Z(s, t) = \overline{Z}(\blacksquare, \blacksquare) + [\overline{Z}(s, \blacksquare) - \overline{Z}(\blacksquare, \blacksquare)] + [\overline{Z}(\blacksquare, t) - \overline{Z}(\blacksquare, \blacksquare)]$$

= overall mean + site effect + time effect.

Variance due to interaction is the mean squared difference between the left and right sides = the mean square of the error you would make if you assumed Z(s, t) was additive.

The message of the starred variance formula is:

If sites vary more than times ($\sigma_S^2 > \sigma_T^2$), choose more sites (large m);
If times vary more than sites ($\sigma_T^2 > \sigma_S^2$), choose more times (large n).

This message is oversimplified, but is still a useful guide. It ignores the interaction term, but this is reduced by increasing either m or n, and usually plays a smaller role: σ_{Int}^2 is unlikely to be larger than both σ_S^2 and σ_T^2 (since sites are likely to go up or down similarly over time, though not exactly) and its divisor (mn) is larger.

The model is also oversimplified. In practice, the random selection of sites would be "spatially balanced" so that sites will not be chosen too close together. However, this and the even spread of times, are responses to variation. They separate the range of sites, R, or the range of times, T, into strata that are more homogeneous than R or T as a whole. The number of strata needed for a factor (sites or times) will tend to be higher when the factor is more variable.

We don't know σ_S^2 or σ_T^2 (or σ_{Int}^2). However, we often have some idea at the outset as to whether Z varies more over space or over time, especially if there are preliminary data. If the over simple analysis is biased, it may be in favor of adding times. If multiple observations are taken each year, it might be possible to reduce the variance over time by including a small number of parameters to describe seasonal effects. If so, fewer times would be needed.

In realistic situations there are additional problems. There is usually more than one "Z" (contaminant) and more than one goal (e.g., averages, trends or spikes overall or in subregions). The area of interest can be irregular and poorly defined: for example, a map of "perennial streams (may include) many ephemeral or intermittent streams, or long-dry channels". Sites are not usually equally important or equally accessible. (Strictly, design-based inferences cannot apply to sites that could not have been chosen.)

The design-based approach can be modified to deal with such problems, usually with the aid of an informal model. On average, Z values will differ less between sites that are closer together, so the region can be divided into strata and an appropriate number of sites randomly selected from each stratum. The strata could be defined by other characteristics too. The probability of selection can vary among sites if "there are … scientific, economic, or political reasons for sampling some portions of a resource more intensively than others". The design might allow for updating when the data or other new information cause "the 'important' subpopulations (to) change, necessitating a corresponding change in sampling intensity" or we find that some planned sites are unusable. These quotes and a design with these three features (generalized random-tessellation stratified: GRTS) are given by Stevens and Olsen (2004). Standard methods allow estimates of means and other simple (linear) summaries; estimates of SE are harder. They illustrate the design in four surveys of Indiana river systems. See also Chapter 6 in Gitzen et al. (2012).

The GRTS design is over space. When sampling is over time as well, new decisions are needed. In practice, as above, times may be equally spaced (perhaps within a season). Observations at different times are assumed to be independent, but small time gaps may cause dependence which needs to be modeled. "Panel plans" have different visiting schedules for different groups of sites (panels), so more sites are covered but less often. For example, two panels may be visited in years 1, 3, 5, … and 2, 4, … respectively. There are many such plans: e.g., see Urquhart and Kincaid (1999).

The aim of this discussion is not to urge adoption of some design off the shelf. It is to make two points. The first is that all useful monitoring plans

(a) have goals that require linking observations taken at different times or sites into estimates of summaries, like means or trends, which can help determine management actions, and
(b) give the reliability of these estimates a major role in the selection of sampling times and sites.

The second is that methods for achieving these goals have been studied for several decades by many able people. None have developed designs specifically for the Delta RMP, but even the simple models can provide guidance (as above), and it is likely that some of their more detailed work can be used. The references below may help, especially the book by Gitzen et al (2012). However, this is a very short list. More important is a team member who can use these and other references to work with the rest of the team to develop a monitoring plan that attends to items (a) and (b) above and clearly addresses the management and assessment questions.

DATE: October 6, 2016

TO: Delta RMP Steering Committee and Technical Advisory Committee

FROM: Adam Laputz

RE: Delta RMP Independent Panel Review

The Delta Science Program's Independent Panel completed an initial draft review of the Delta RMP Monitoring Design (attached). The initial review includes some general suggestions such as considering tides and other temporal factors in choosing sampling sites and schedule, while also providing specific suggestions for each of the four priority constituents. Using statistics in the sampling design is one of the main suggestions and takes up some discussion including a very technical appendix addressing various statistical considerations when developing a monitoring design. The report also includes many questions from the review panel regarding aspects of the design, which may be useful for the authors composing the response letter.

The next steps are for the Delta RMP to prepare a response to the initial review, after which the Independent Panel will finalize the review. Specifically, the process will be:

· The Steering Committee and TAC will discuss the findings in the initial review at the joint meeting on 10/18/16.

· TAC and technical subcommittee members are encouraged to provide responses to the External Review Planning Committee, a subcommittee of the SC, by 12/1/16 (send them to philt@sfei.org).

· The Planning Committee will prepare a draft response by 12/31/16.

· The draft response will be discussed at the 1/26/17 SC meeting and then finalized.

· The Independent Panel will consider the comments for revisions to the report and issue a final report approximately one month after receiving SC response.

Please contact me if you have any questions. Thank you.

Adam Laputz
Central Valley Water Board
(916) 464-4726

Materials for Agenda Item 8

DELTA REGIONAL MONITORING PROGRAM

NUTRIENT MONITORING PLANNING WORKSHOP

DRAFT REPORT

SUMMARY OF EXISTING NUTRIENT MONITORING PROGRAMS, DATA GAPS, AND POTENTIAL DELTA RMP "NO REGRETS" MONITORING ACTIVITIES

DRAFT REPORT, POST-WORKSHOP: October 8, 2016

1. Introduction and Objectives for Workshop

The Delta Regional Monitoring Program (RMP) Steering Committee has approved a list of management questions and assessment questions for nutrients in the Delta (Table 1). The data needed to answer these questions will come from a combination of existing monitoring programs and new data collection efforts to fill data gaps.

The Delta RMP only started to collect samples in the spring of 2015. Current priorities are mercury, nutrients, pathogens, and pesticides. Sample collection has begun for mercury, pathogens, and pesticides.

Deciding how to invest in monitoring resources for nutrients is challenging for a few reasons:

1. The Delta is a complex system in terms of hydrology, ecology, and water quality. There is disagreement as to its trophic status and the value (or harm) of current nutrient loadings.
2. There are numerous potential issues to address relative to nutrients, with limited resources.
3. Delta nutrients are already being monitored by other agencies, only some of which participate in the Delta RMP. There is not a common and agreed-on framework for coordination. While some of these efforts are long-term and consistent, other activities are shorter-term, or special studies, or have no secured future funding.

This report reflects feedback received at a Delta RMP nutrient monitoring planning workshop held on September 30, 2016. The goals of this workshop were to:

- **Identify** how much of the nutrient monitoring needed to answer the Delta RMP assessment questions is already happening through **existing programs,**
- Identify critical nutrient data **gaps** for the Delta RMP and develop "no regrets" monitoring activities to fill them (beginning in Calendar year 2017), and
- Develop **budget estimates for "no regrets"** monitoring activities to facilitate multi-year budget planning for the Delta RMP multi-year plan

The purpose of this report is to compile information from the major nutrient monitoring programs and to outline options for "no regrets" actions for workshop participants to review. The report synthesizes the information and recommendations gathered in a) interviews with representatives of Delta monitoring and resource management programs, b) updating earlier information gathered on current monitoring efforts in the Delta (Central Valley Monitoring Directory, Jabusch and Gilbreath 2010), and c) conclusions and recommendations from recently completed data syntheses by ASC (Novick et al. 2015, Jabusch et al. 2016) and USGS (Bergamaschi et al., in press).

Table 1. Delta RMP assessment questions for nutrients. ***Italicized bold-faced questions*** are the highest priority for the initial program.

Type	Core Management Questions	Nutrient Assessment Questions
Status & Trends	***Is there a problem or are there signs of a problem?*** a. Is water quality currently, or trending towards, adversely affecting beneficial uses of the Delta? b. Which constituents may be impairing beneficial uses in subregions of the Delta? c. Are trends similar or different across different subregions of the Delta?	***ST1. How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally?*** ***A. Are trends similar or different across subregions of the Delta?*** ***B. How are ambient levels and trends affected by variability in climate, hydrology, and ecology?*** ***C. Are there important data gaps associated with particular water bodies within the Delta subregions?*** ST2. What is the current status of the Delta ecosystem as influenced by nutrients? A. What is the current ecosystem status of habitat types in different types of Delta waterways, and how are the conditions related to nutrients?
Sources, Pathways, Loadings & Processes	Which sources and processes are most important to understand and quantify? a. Which sources, pathways, loadings, and processes (e.g., transformations, bioaccumulation) contribute most to identified problems? b. What is the magnitude of each source and/or pathway (e.g., municipal wastewater, atmospheric deposition)? c. What are the magnitudes of internal sources and/or pathways (e.g. benthic flux) and sinks in the Delta?	***SPLP1. Which sources, pathways, and processes contribute most to observed levels of nutrients?*** ***A. How have nutrient or nutrient-related source controls and water management actions changed ambient levels of nutrients and nutrient-associated parameters?*** ***B. What are the loads from tributaries to the Delta?*** ***C. What are the sources and loads of nutrients within the Delta?*** ***D. What role do internal sources play in influencing observed nutrient levels?*** ***E. Which factors in the Delta influence the effects of nutrients?*** ***F. What are the types and sources of nutrient sinks within the Delta?*** ***G. What are the types and magnitudes of nutrient exports from the Delta to Suisun Bay and water intakes for the State and Federal Water Projects?***
Forecasting Scenarios	a. How do ambient water quality conditions respond to different management scenarios b. What constituent loads can the Delta assimilate without impairment of beneficial uses? c. What is the likelihood that the Delta will be water quality-impaired in the future?	FS1. How will ambient water quality conditions respond to potential or planned future source control actions, restoration projects, and water resource management changes?

2. Executive Summary

What Are the Existing Monitoring Activities Relevant to Delta RMP Assessment Questions?

Long-term routine monitoring, short-term studies, and continuous monitoring networks care collecting nutrient and nutrient-associated data at more than 100 stations in and around the Delta (Figure 1).

Long-term routine monitoring programs include the California Department of Water Resources Environmental Monitoring Program (DWR-EMP, 17 sites, since 1975), the DWR Municipal Water Quality Investigations (MWQI, 14 sites, since 1982), the U.S. Geological Survey (USGS) National Water Quality Assessment Program (NAWQA, 2 sites, since 1991), the USGS San Francisco Bay water quality cruise (5 sites each in the Delta and Suisun Bay, since 1969), and Regional San's and the Stockton regional wastewater treatment facilities' ambient water quality monitoring (2 sites each, since 2010 and 1992, respectively).

Short-term studies. Currently active monitoring studies include the MWQI DSM2 nutrient study (5 sites, since 2013), the MWQI Cache Slough Baseline Monitoring Study (11 sites, since 2013), an IEP-funded Sacramento Deepwater Ship Channel (SDSC) study (12 sites, since 2012), and a Regional San research survey (15 sites, 2016).

Continuous monitoring networks include the USGS high-frequency (HF) sensor network (11 sites, since 2013), MWQI Real-Time Data and Forecasting (RTDF) (4 sites, since 1982), EMP chlorophyll sensors (15 sites, since 1971), and DWR North Central Regional Office (NCRO) chlorophyll sensors (24 sites, since 1991).

To What Extent Are These Monitoring Activities Addressing Delta RMP Assessment Questions?

Status & Trends

Overall, the existing monitoring programs provide partial coverage of the Delta RMP's S&T assessment questions (we estimate ~50% coverage; see Table 4).

Long-term routine monitoring programs cover the water column of main channels fairly well. Several short-term studies also provide temporary coverage of some under-monitored areas, including the North Delta. The USGS sensors provide high-frequency data at 11 stations in the North Delta, Sacramento River, Confluence, and South Delta. DWR programs maintain chlorophyll sensors in the Confluence, Central Delta, South Delta, North Delta, Sacramento River, and Suisun Bay subregions.

Sources, Pathways, Loadings, and Processes (SPLP)

Overall, the existing monitoring programs provide limited (we estimate ~25%) coverage for the Delta RMP's SPLP assessment questions.

The existing monitoring activities of USGS and DWR provide good coverage of the types and magnitudes of nutrient loads from the major tributaries, and exports from the Delta to the State and Federal water projects and to Suisun Bay.

The USGS sensor network provides baseline monitoring to help understand SPLP questions at some key locations in the North Delta, Sacramento River, and

the confluence. Future funding for this network is uncertain.

What are the Most Critical Remaining Data Gaps?

Status and Trends

Spatial Coverage

There is little monitoring coverage of shallow waters and the margins of the Delta and Suisun Bay.

There is no long-term routine monitoring in the Eastside tributaries, large areas of the Central, North, and South Delta, the Sacramento River subregion outside the mainstem Sacramento River, and in Suisun Marsh.

Nutrients and Ecosystem Conditions

Addressing gaps in all biological assessment programs is beyond the scope of this report. However, there are some obvious critical gaps, such as program modules that specifically target harmful algae and algal toxins, and a sampling network optimized for detecting and characterizing “beneficial blooms” that support the food web."

In the future, the Delta RMP should go through a similar exercise to identify links between nutrient monitoring and biological endpoints.

Sources, Pathways, Loadings, and Processes

Nutrient Sources to the Delta

Overall, estimates of nutrient loads from tributaries upstream are highly likely to be biased low, because storm events and smaller tributaries are not adequately captured.

Sources and Sinks within the Delta

Nutrient sinks and sources (and especially agricultural sources) in the Delta represent a critical data gap. The current monitoring does not provide the data needed to fill it.

Pathways

Hydrologic sources and source mixing have not been fully evaluated at a number of key Delta in- and outflows. Hydrologic modeling funded by the Delta RMP is expected to fill some of the gaps.

Loadings

POTW compliance monitoring provides good coverage of point source loadings within the Delta, but non-point source loads (agricultural, atmospheric, and others) are poorly understood.

Processes

Data needs for the development of a mechanistic water quality-hydrodynamic model include

- Nutrient model constituents (ammonia, nitrate, nitrite, organic-N, orthophosphate, organic-P, DO, total phytoplankton biomass, EC, temperature, BOD, CBOD).
- Rates and controls on nutrient uptake and transformation at the water/sediment interface and in wetlands
- Baseline data on the microbial foodweb and its role in nutrient cycling
- Biomass of aquatic vegetation.

Forecasting Scenarios

Current models are not ready for this use, in part because specific data are missing to validate rate constants for

uptake and loss of nutrients. Current models also cannot evaluate the effects of nutrients on ecosystem conditions fully enough to answer Delta RMP questions.

Potential Delta RMP Activities to Fill These Gaps

The main objective of this report is to identify options for a few concrete tasks that could be implemented by the Delta RMP to address some of the critical data gaps without the risk of wasting resources. To that end, the following "no regrets" options have been developed for consideration by the Delta RMP committees (Figure 1).

1. Coordination and Integration

Option 1a. Coordination Workshops – FOUNDATIONAL ACTIVITY

Convene one or several workshops on the topic of monitoring coordination, model input needs, and methods consistency. A number of Delta RMP data needs could be met if monitoring agencies were enabled to coordinate on sampling designs, sampling protocols, interlaboratory measurement consistency, and data needs for models.

Option 1b. Coordination and Integration Tools – FOUNDATIONAL ACTIVITY

Update and maintain a master list/inventory and develop an online monitoring tool of who monitors what, where, and when. This would allow for a thorough evaluation of data gaps and places where additional sampling, analyses, and increased sampling frequencies could be "piggybacked" on the existing programs. Long-term goals are to identify ways the current resources could be more efficiently and effectively applied; foster communication and collaboration; and identify opportunities for leveraging existing sampling efforts.

2. Status and Trends

Option 2a. "Piggybacking" – FILLS SPATIAL, TEMPORAL, AND PARAMETER GAPS

"Piggybacking" involves the addition of new stations, parameters, and increased sampling frequency *to existing routine monitoring programs*. Resuming monitoring at discontinued EMP stations and/or adding new stations (1-4 total) in under-monitored areas would increase the density and representativeness of spatial coverage. Adding parameters or increasing the frequency of monitoring at existing stations would address parameter and temporal data gaps.

Based on the current inventory of monitoring programs, several obvious data gaps have been identified. However, a certain amount of planning must be completed before decisions are made about how to augment the existing monitoring network.

Option 2b. HAB Sampling – FILLS CONSTITUENT GAPS

This option would fill a critical monitoring gap. The initial focus of this monitoring would be on addressing one or several of multiple objectives: 1) public health and ecosystem concerns, 2) gaining a better understanding of bloom dynamics, and/or 3) their spatial and temporal extent.

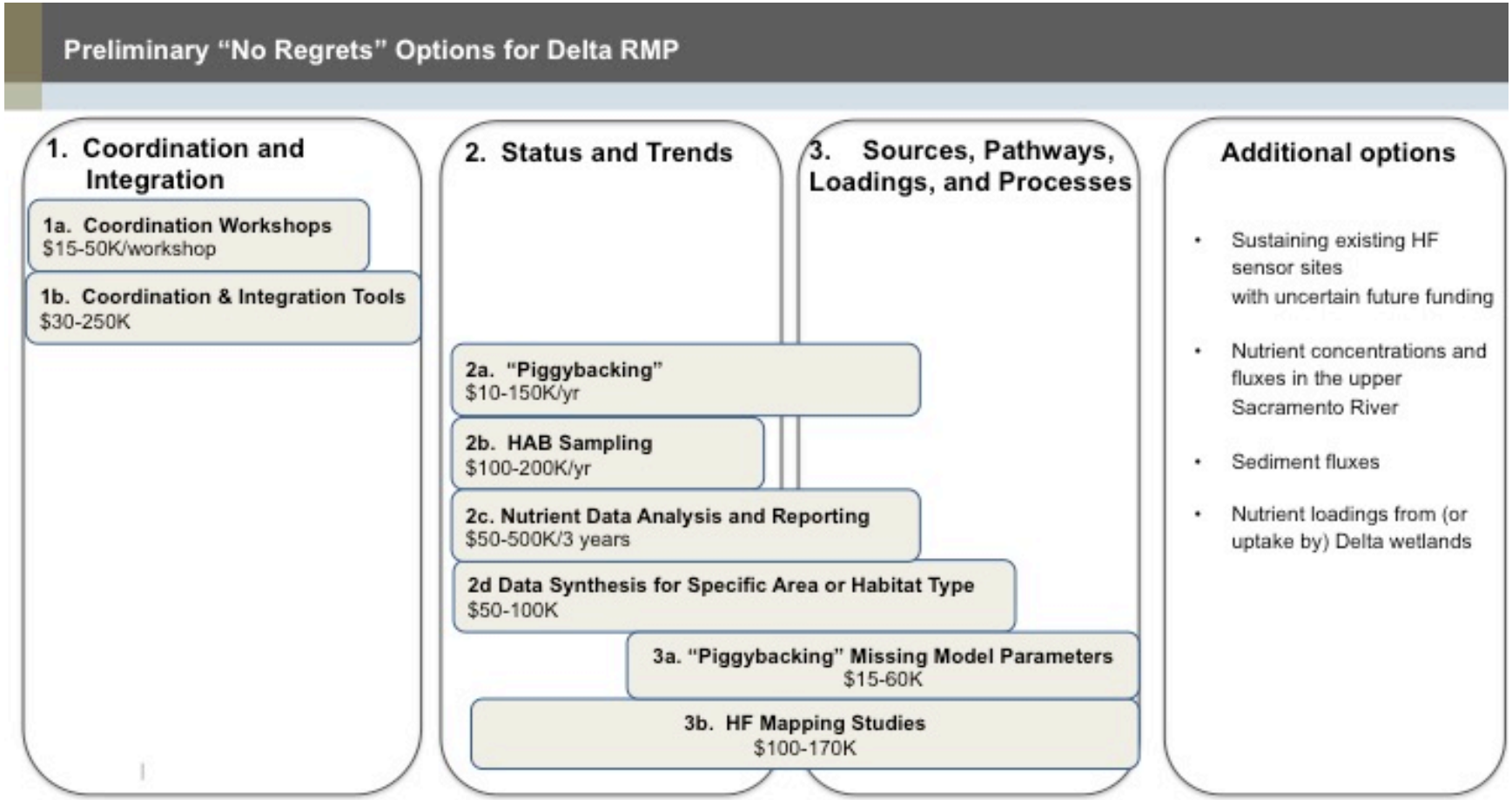


Figure 1.Summary of recommended "no regrets" options for the Delta RMP.

Option 2c. Nutrient Analysis and Reporting – INFORMS FUTURE DESIGN

Continued synthesis and integration of existing data to evaluate the information they provide relative to the Delta RMP assessment questions. Existing nutrient and nutrient-associated data are underutilized. Synthesizing, assessing, and reporting on the wealth of data generated by monitoring agencies could be a valuable function of the Delta RMP. A biannual report presenting the synthesized information could be produced, which provides the current state of knowledge in answering the Delta RMP assessment questions related to nutrient trends and effects.

Option 2d. Nutrient Data Synthesis for Specific Area or Habitat Type – INFORMS FUTURE DESIGN

Data analysis should also extend to more specific information gaps, such as under-monitored and under-analyzed subregions or habitats for which data exist but have not been synthesized and assessed against the Delta RMP assessment questions.

At the workshop, participants specifically discussed the idea of a North Delta Synthesis. A North Delta data analysis would synthesize and assess data available for this region, including HF sensor monitoring, MWQI data collection efforts, and for the SDSC special study. The North Delta is considered an under-monitored geographic area where important biogeochemical processes occur.

However, analyses of other subregions or habitat types might be considered equally important. For example, there are major problems with HABs, macrophytes, and dissolved oxygen (DO) in the South Delta. Thus, a certain amount of planning must still be completed before decisions are made about scope and goals of the syntheses.

3. Sources, Pathways, Loadings, and Processes

Option 3a. "Piggybacking" Missing Model Parameters – DATA FOR MODELS

Augment the suite of parameters analyzed on discrete samples at certain sites to include those that are needed for water quality models.

Option 3b. High Frequency Sensor Mapping Studies – DATA FOR MODELS

Use high frequency sensor data collection cruises to map nutrients and other parameters in subregions to understand nutrient transformations and potential internal loading in under-sampled Delta locations.

The total cost to implement all these options ranges is estimated to be $370,000 to $1,480,000 per year.

Implementation of these options would make good progress toward filling the data gaps for Status and Trends and some progress on the data gaps for Sources, Pathways, Loadings and Processes. Development of water quality models for the Delta is a critical step for understanding sources pathways and processes. Model development is a huge undertaking (estimated annual cost of $1.7M see Trowbridge et al., 2016) that will need to be well planned and have funding from multiple sources.

3. Summary of Existing Nutrient Monitoring in the Delta

Existing monitoring programs are collecting nutrient and nutrient-associated data at more than 100 stations in and around the Delta (Figure 2). At least eight different entities are involved in the data collection. These programs include:

(1) *Long-term routine monitoring* programs that are collecting nutrient and nutrient associated data in and around the Delta on an ongoing basis. These include the California Department of Water Resources Environmental Monitoring Program (DWR-EMP), the DWR Municipal Water Quality Investigations (MWQI), the U.S. Geological Survey (USGS) National Water Quality Assessment Program (NAWQA), and Regional San's ambient water quality monitoring. The **EMP** conducts monthly monitoring of general water quality and nutrients (17 sites in the Delta and Suisun Bay), phytoplankton (16 sites), and zooplankton (20 sites) at 14 sites representing main in- and outflows of the Delta. **MWQI** conducts monthly water sampling at main Delta in and outflows and at sites located near water agency intakes. Constituents monitored by MWQI include nutrients and organic carbon (OC). **NAWQA** visits two sites representing the entry points of the Sacramento and San Joaquin rivers to the Delta, Freeport @ Sacramento River (14 times/year) and Vernalis @ San Joaquin River (18 times/year). **Regional San** conducts monthly monitoring at two sites upstream and downstream of the Sacramento Regional Wastewater Treatment Plant. The **Stockton Regional Wastewater Control Facility (RWCF)** conducts monthly monitoring at two sites upstream and downstream of the facility. As part of the HF monitoring network (described below), the **USGS** California Water Science Center (CAWSC) Biogeochemistry Group collects monthly discrete samples at all HF stations (except Vernalis, which DWR monitors). These data are used to calibrate and validate the sensor data, but are also uploaded to NWIS. Analytes include NH4, NO2, NO3, PO4, DOC. TDN, Chl-a, TSS, and optical properties. The USGS San Francisco Bay Water Quality Cruise collects monthly water quality measurements at multiple depths along a transect that extends to Suisun Bay and the Confluence region of the Delta up to Rio Vista on the Sacramento River. Constituents include NO_2^-, NO_3^-, NH_3, PO_4 and dissolved Si.

(2) *Continuous monitoring networks* that are maintained by the USGS and DWR. The USGS CAWSC Biogeochemistry Group currently operates 11 high frequency stations in the Delta: 2 in the Sacramento River subregion, 5 in the North Delta subregion, 3 in the Confluence subregion, and 1 at Vernalis in the South Delta

subregion. **MWQI** maintains one continuous sensor station at Hood, 2 at the South Delta pumps, and 1 inside the State Water Project (SWP) aqueduct. Sites at the pumps and inside the SWP are equipped with a selective ion detector that can measure NO3. All MWQI continuous sites measure chlorophyll and OC. The **EMP** maintains fifteen chlorophyll sensors representing main in- and outflows of the Delta, Suisun Bay, and Suisun Marsh. The DWR North Central Regional Office (**NCRO**) maintains 24 additional chlorophyll sensors in the Central and South Delta.

(3) *Short-term Special Studies* that are currently collecting nutrient and nutrient-associated data at 40 additional locations. The MWQI **DSM2 nutrient study** conducts bimonthly visits to 5 sites representing DSM2 (Delta Simulation Model 2) nodes. The MWQI **Cache Slough Baseline Monitoring Study** conducts bimonthly visits to 11 sites in and around the Cache Slough complex in the North Delta. Both studies have no confirmed sunset date. A IEP-funded monitoring campaign to study the Sacramento Deepwater Ship Channel (**SDSC**) conducts monthly transects at 12 sites from Antioch to the North Delta, to measure nutrients along with other foodweb-related parameters. **Regional San** is about to complete an intensive research survey of phytoplankton growth conditions - including nutrients - at 15 sites along the mainstem Sacramento River.

The major monitoring programs and special studies are listed in Table 2. Station locations for these programs are summarized in Figures 2a (Long-term monitoring programs) and 2b (Short-term special studies). In Appendix A, there is more information about each of the programs. The appendix summarizes

- How and to what extent it addresses Delta RMP assessment questions
- Opportunities
- Constraints
- Program description: Start date, sampling frequency, nutrients monitored, nutrient associated variables monitored
- Sampling locations
- Data availability and reporting.

The scope of this report was limited to evaluating the major nutrient monitoring programs in the Delta. There are other programs that monitor for nutrients (e.g., ILRP, restoration projects, stormwater agencies, DWR O&M). These other programs, and any others that are missing, should be included in any comprehensive inventories of nutrient monitoring.

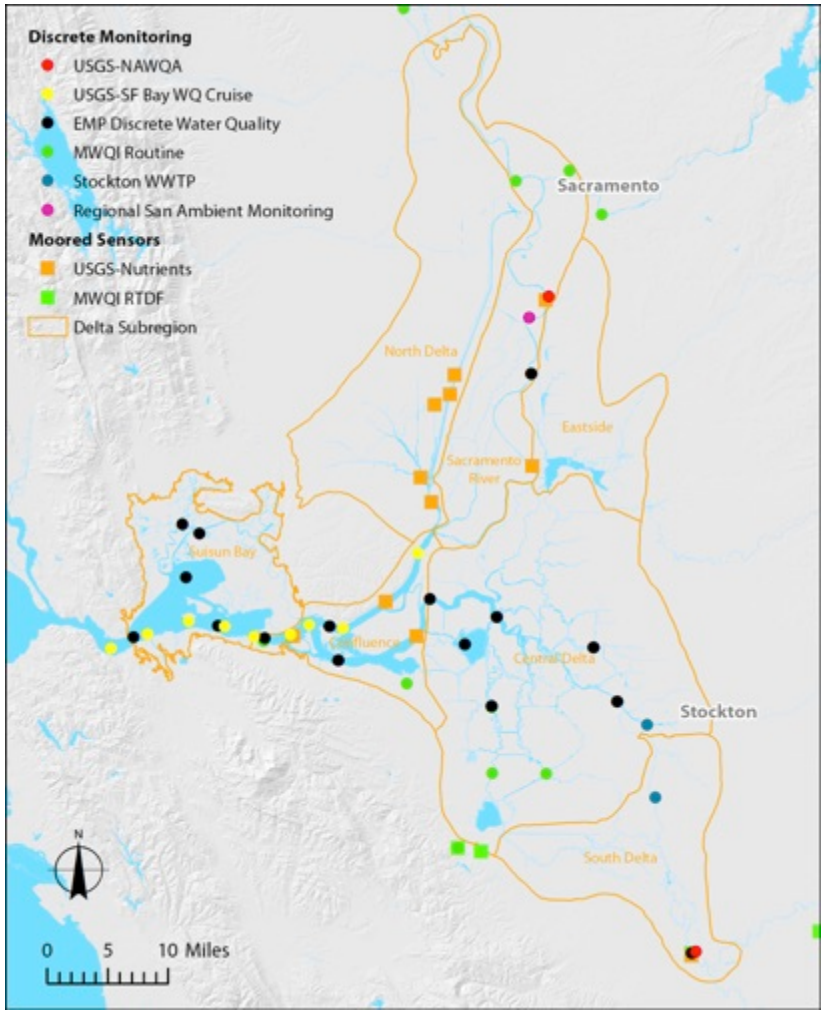


Figure 2a. Current nutrient monitoring locations in the Delta, long-term sites. Proposed subregions: Sacramento River, North Delta, Eastside, Central Delta, South Delta, and Suisun Bay, as described in a recent ASC synthesis report funded by the Delta Science Program (Jabusch et al. 2016).

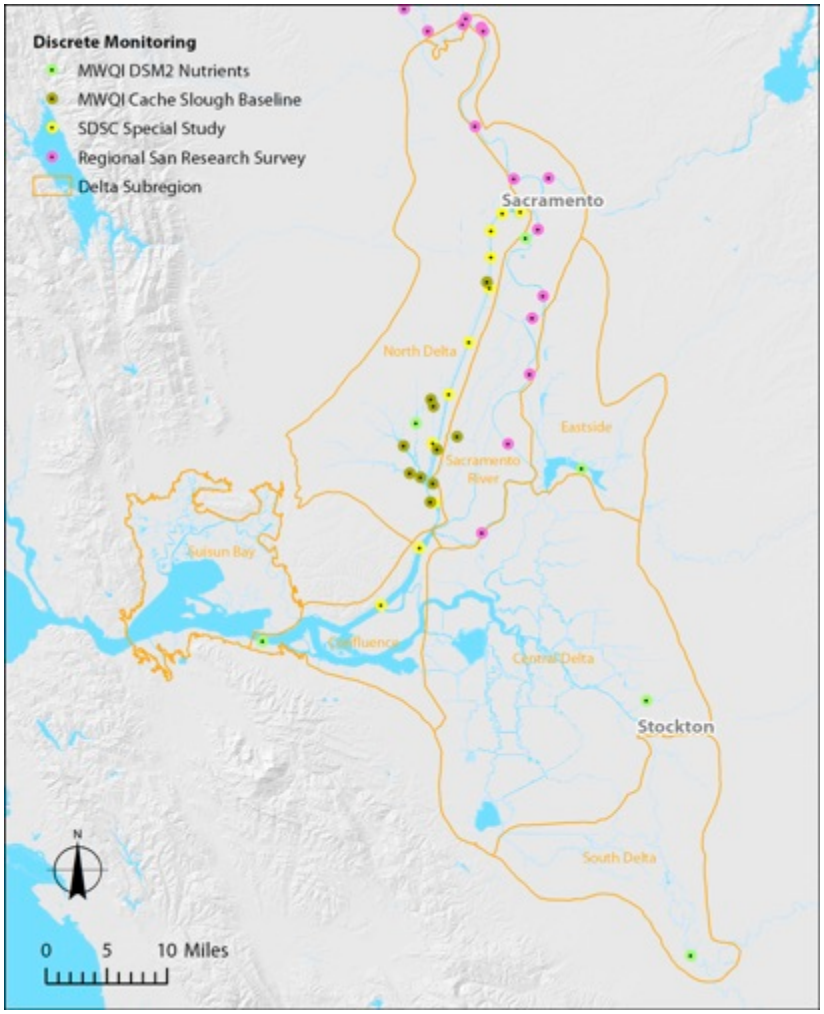


Figure 2b. Current nutrient monitoring locations in the Delta, short-term sites.

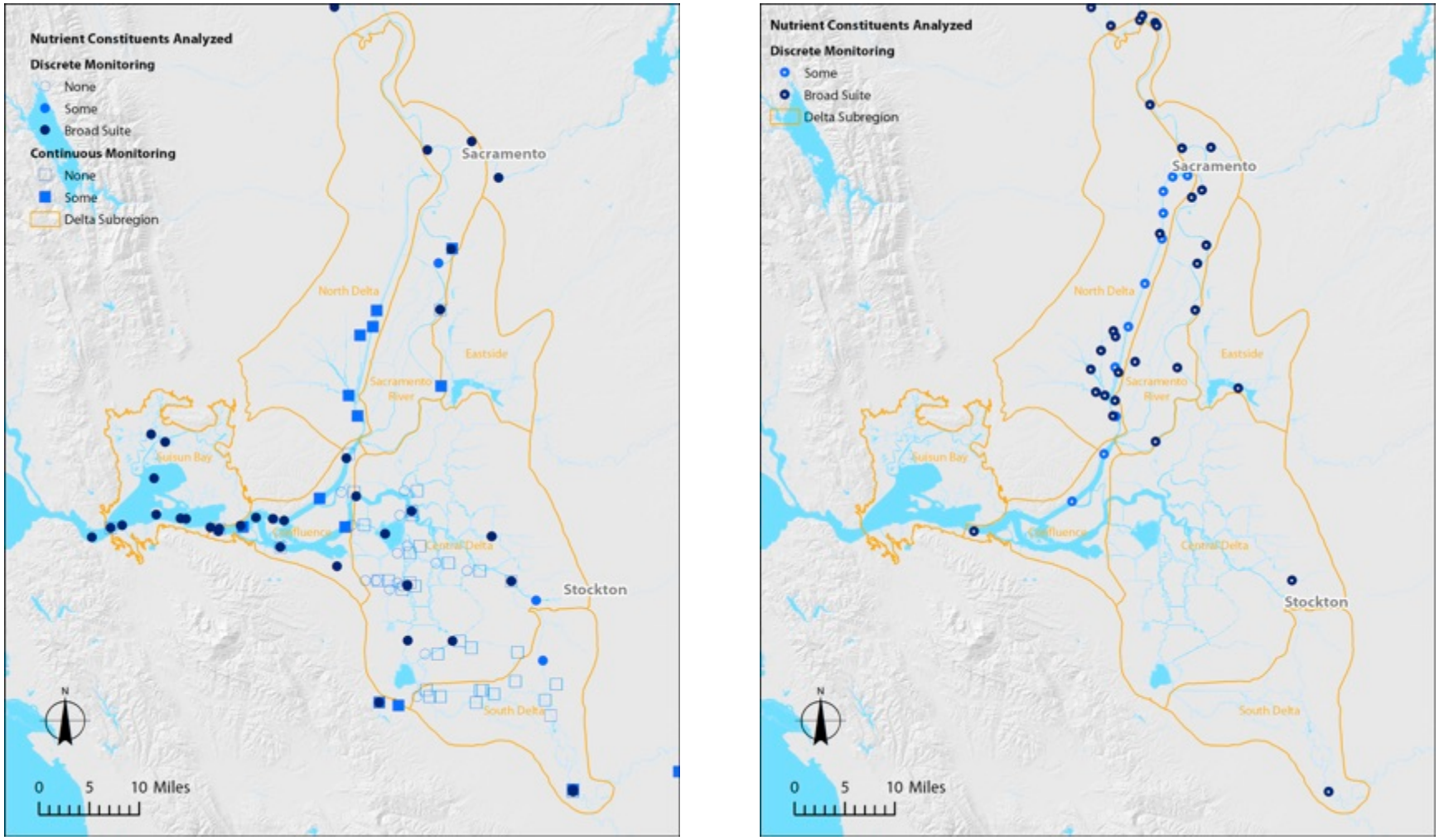


Figure 3. Current long-term (left) and short-term nutrient monitoring locations in the Delta. For each location, the color scale indicates if monitoring captures a broad suite of nutrient and nutrient-associated parameters, only some, or none (for stations that only monitor nutrient-associated variables such as chl or DO).

Table 2. Overview of monitoring programs collecting nutrient and nutrient-associated data.

Program	Since when?	How often?	Where?	What?	Public data access?
Long-term Monitoring					
California Department of Water Resources (DWR) – Environmental Monitoring Program (EMP)					
Discrete Water Quality	1975	Monthly	Northern San Francisco Estuary 12 sites in Delta representing main in- and outflows, 5 in Suisun Bay 3 Delta sites (Hood, Vernalis, Old R @ Rancho del Rio) co-located with flow	**Nutrients:** Ammonia, Kjeldahl nitrogen, nitrite + nitrate, organic nitrogen, ortho-phosphate, phosphorus, silica **Nutrient-associated:** Chlorophyll a, phaeophytin a; general water quality and standard minerals (calcium, EC, TDS, TSS, VSS); DOC, TOC; field measurements (DO, EC, fluorescence, pH, temperature, turbidity, Secchi depth)	http://www.water.ca.gov/bdma/meta/Discrete/data.cfm
Continuous Water Quality	1971	Every 15 minutes	15 sites representing the main inflows and outflows of the Delta, Suisun Bay, and Suisun Marsh (all Delta sites except Confluence sites co-located with flow)	**Nutrient-associated:** Chlorophyll, DO, EC, pH, temperature, turbidity	http://www.water.ca.gov/bdma/meta/continuous/data.cfm
Phytoplankton - Long-term	1975	Monthly	Northern San Francisco Estuary 11 sites in Delta, 5 in Suisun Bay, representing different aquatic habitats 3 Delta	**Nutrient-associated:** Phytoplankton abundance and taxonomic composition	http://www.water.ca.gov/bdma/meta/Phytoplankton/data.cfm

Program	Since when?	How often?	Where?	What?	Public data access?
			sites (Hood, Vernalis, Old R @ Rancho del Rio) co-located with flow		
Zooplankton	1968	Monthly	Northern San Francisco Estuary Currently, 20 fixed stations (10 in Delta, 5 in Suisun Bay) and between 2 and 4 floating entrapment zone stations	**Nutrient-associated:** Zooplankton abundance and taxonomic composition	http://www.water.ca.gov/bdma/meta/zooplankton/data.cfm
DWR – Municipal Water Quality Investigations (MWQI)					
Routine Monitoring	1982	**Discrete:** Monthly	Main inflows and outflows of the Delta 9 sites in the Delta, 4 upstream in Sacramento River watershed, 1 in State Water Project (SWP) downstream. Most Delta sites co-located with flow.	**Nutrients:** Ammonia, Kjeldahl nitrogen, nitrite + nitrate, organic nitrogen, ortho-phosphate, phosphorus Nutrient-associated: UVA, standard minerals, DOC, TOC, turbidity	http://www.water.ca.gov/waterdatalibrary/
Real-time Data and Forecasting (RTDF)	1982	**Continuous:** Every 15 minutes	4 sites at main inflows and outflows of the Delta, one in SWP of the Delta at the Gianelli Pumping/Generating Plant All stations are co-located with flow	**Nutrients:** nitrate (Ion Chromatography Analyzer) **Nutrient-associated:** EC, TOC/DOC	http://cdec.water.ca.gov/queryTools.html
U.S. Geological Survey (USGS)					

Program	Since when?	How often?	Where?	What?	Public data access?
National Water Quality Assessment Program (NAWQA)	1991	**Discrete:** 14 events/year (Freeport)/18 events/year (Vernalis) Grab sampling from bridge (Vernalis)/by boat (Freeport)	Sacramento and San-Joaquin-Tulare basins 2 sites in Delta (both co-located with flow)	**Nutrients:** Ammonia, nitrate, nitrite, total nitrogen, orthophosphate, total phosphorus, organic nitrogen **Nutrient-associated:** Dissolved and particulate carbon, ultraviolet light absorbing constituents	http://waterdata.usgs.gov/nwis
CAWSC Biogeochemistry Group High Frequency (HF) Nutrient Monitoring Network	2013 Future funding uncertain	**Continuous**, Every 15 minutes for in situ HF measurements **Discrete**: Grab sampling by boat each, approximately monthly	11 Stations: 2 in the Sacramento River subregion, 5 in the North Delta subregion, 3 in the Confluence subregion, and 1 at Vernalis in the South Delta subregion. Discrete samples are collected at these stations monthly Stations co-located with flow: Freeport and Walnut Grove (Sacramento River); Liberty Island and Cache Slough (North Delta); Jersey point (Confluence); and Vernalis (South Delta)	**Continuous, Nutrients:** Nitrate, phosphate (sensors deployed on an event basis), ammonium (under development) **Continuous, Nutrient-associated sensors:** Temperature, conductivity, pH, DO, turbidity, chlorophyll-a, phycocyanin (a tracer for blue-green algae such as *Microcystis*), and fluorescent dissolved organic matter (fDOM, a proxy for dissolved organic carbon concentrations). **Discrete, nutrients:** include NH4, NO2, NO3, PO4, TDN.	

Program	Since when?	How often?	Where?	What?	Public data access?
				Discrete, nutrient-associated: Chl-a, DOC, TSS, and optical properties.	
DWR – North Central Region Office (NRCO) Water Quality Evaluations					
Central Delta Monitoring – Continuous	2007	**Continuous:** Every 15 minutes	10 sites representing critical areas of the Central Delta to characterize water quality on the path that Sacramento River water takes to Clifton Court Forebay. All sites are co-located with flow. .	**Nutrient-associated:** Chlorophyll, temperature, SC	http://www.water.ca.gov/waterdatalibrary/
Central Delta Monitoring – Discrete		**Discrete:** Grab sampling by boat or shoreside upon each continuous monitoring site visit (can vary from weekly to every 3 weeks)		**Nutrient-associated:** Chlorophyll, phaeophytin, TSS	http://www.water.ca.gov/waterdatalibrary/
Rock Slough Monitoring – Continuous	2001	**Continuous:** Every 15 minutes	5 monitoring stations between Old River and Contra Costa Canal. One site co-located with flow: Old R @ Bacon Island.	**Nutrient-associated:** SC, temperature	http://www.water.ca.gov/waterdatalibrary/
Rock Slough Monitoring – Discrete		**Discrete:** Grab sampling by boat or shoreside upon each continuous monitoring site visit (can vary from weekly to every 3 weeks)		**Nutrient-associated:** SC, temperature	http://www.water.ca.gov/waterdatalibrary/
South Delta Monitoring – Continuous	1991	**Continuous:** Every 15 minutes	14 monitoring stations in the South Delta and southern Central Delta. Six sites are co-located with flow: Grant Line Canal: above barrier & nr Clifton Court Forebay; Middle	**Nutrient-associated:** Chlorophyll, DO, pH, temperature, turbidity, SC	http://www.water.ca.gov/waterdatalibrary/
South Delta Monitoring – Discrete		**Discrete:** Grab sampling by boat or shoreside upon each continuous		**Nutrient-associated:** Chlorophyll, phaeophytin, TSS	http://www.water.ca.gov/waterdatalibrary/

Program	Since when?	How often?	Where?	What?	Public data access?
		monitoring site visit (can vary from weekly to every 3 weeks)	R @ Union Pt.; Old R: @ DMC - below dam & @ Tracy Wildlife Association; Victoria Canal nr Byron		
National Pollution Discharge Elimination System (NPDES)					
POTW effluent monitoring	Varies by facility	Varies by facility, depending on discharge volume and parameter (daily - annual)	15 NPDES facilities located in the Delta and 40 upstream (below major dams) in the Central Valley.	Typical effluent monitoring include ammonia and nitrate+nitrite, some facilities also measure total Kjeldahl Nitrogen and total phosphorus Nutrient-associated: pH	https://ciwqs.waterboards.ca.gov/ciwqs/readOnly/CiwqsReportServlet?inCommand=reset&reportName=esmrAnalytical
Regional San					
Ambient water quality (Receiving Water)	2010 End date TBD	Monthly grab sampling by boat	2 sites, Freeport and Cliff's Marina (Freeport site co-located with flow)	**Nutrients:** Ammonium, total nitrogen	
Stockton RWCF					
Ambient water quality (Receiving Water)	2016 End date TBD	Monthly grab sampling by boat	2 sites, up- and downstream of facility	**Nutrients:** Ammonium **Nutrient-associated:** salinity, temperature, pH, turbidity, DO	
Short-term Studies					
DWR – MWQI					
DSM2 Nutrient Study	2013 End date TBD	**Discrete:** Twice a month Grab sampling by boat	DSM2 nodes 5 sites in the Delta. One station (SJR @ Vernalis) is co-located with flow.	**Nutrients:** Ammonia, Kjeldahl nitrogen, nitrite + nitrate, organic	http://www.water.ca.gov/waterdatalibrary/

Program	Since when?	How often?	Where?	What?	Public data access?
				nitrogen, ortho-phosphate, phosphorus **Nutrient-associated:** Physical parameters, biological oxygen demand (BOD), carbonaceous biological oxygen demand (CBOD), chlorophyll, and phaeophytin	
Cache Slough baseline monitoring and analysis	2013 End date TBD	**Discrete:** Twice a month Grab sampling by boat	11 sites in Cache Slough Complex, Prospect Slough stairstep, and Liberty Cut, Sacramento Deepwater Ship Channel (SDSC) 4 sites are co-located with flow: Cache Slough, Liberty Island, Miner Slough, and Lisbon Weir.	**Nutrients:** Ammonia, Kjeldahl nitrogen, nitrite + nitrate, organic nitrogen, ortho-phosphate, phosphorus **Nutrient-associated:** Standard minerals, TOC, DOC, UVA, suspended solids, chlorophyll, phaeophytin	http://www.water.ca.gov/waterdatalibrary/
DWR – EMP-associated Special Studies					
DWR Special Studies Research Program	No current data collection	N/A	N/A	N/A	
US Bureau of Reclamation					
Sacramento Deepwater Ship Channel (SDSC) baseline monitoring	2012 End date TBD	**Discrete:** Monthly in the spring, summer, and fall	12 stations located in the SDSC, the Prospect Slough stairstep, and Liberty Cut. 2 stations co-located with flow: NL 34 (Rio	**Nutrients:** Ammonium, nitrate, soluble reactive phosphorus (SRP) **Nutrient-associated:** Temperature, specific conductance, turbidity,	

Program	Since when?	How often?	Where?	What?	Public data access?
			Vista) and NL 70 in SDSC	suspended solids, phytoplankton and zooplankton abundance and taxonomic composition.	
Regional San					
Research Survey	2016 only	**Discrete:** Intensive one-time surveys in spring and fall, monthly grab sampling at RM44, all by boat. Two stops (Hood, Freeport) are co-located with flow.	15 sites along mainstem Sacramento River and major tributaries.	**Nutrients:** Ammonium, nitrate + nitrite, Kjeldahl N, phosphate, silicate, uptake experiments (NH4+C, NO3+C) **Nutrient-associated:** Temperature, turbidity, pH, EC, DO, chlorophyll, photosynthetically active radiation (PAR), picoplankton, phytoplankton, isotopes, microzooplankton, macrozooplankton, clams.	

4. How Much Are Delta RMP Nutrient Data Needs Already Covered by Existing Programs?

Status & Trends (ST)

ST-1 – How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally? — **ANSWER: PARTIAL OVERALL COVERAGE**

Due to the existence of the 40-year data record generated by the EMP, regional long-term trends are reasonably well understood. Data from additional programs (MWQI, Regional San and IEP special studies) extend the spatial coverage to under-monitored areas in the North Delta and the Sacramento River upstream of the legal Delta. USGS high frequency in situ sensors add temporal resolution for a suite of parameters (NO3, temperature, specific conductivity, DO, pH, turbidity, chlorophyll-a, phycocyanin, fDOM) at stations in the North Delta and Sacramento River subregions. The DWR NCRO monitoring network contributes to the spatial and temporal density of chlorophyll data in the Confluence, Central Delta, South Delta, North Delta, and Sacramento River subregions (see Appendix A, page 47).

The monthly monitoring frequency used by most programs is sufficient for detecting changes in most nutrient-related parameters on the order of 50% change over 10 years. High frequency sensors, where they exist, significantly improve the power to detect trends (see power analysis in Jabusch et al., 2016).

ST-1A – Are trends similar or different across subregions of the Delta?

— PARTIAL COVERAGE

The Delta can be roughly divided into seven subregions for the purpose of status and trends monitoring for nutrient-related parameters (Jabusch et al., 2016). EMP and other programs provide good spatial coverage of these regions but lack stations in the North Delta or Eastside subregions and Suisun Marsh. Recent efforts by MWQI and USGS started filling some of these gaps but their continuation is uncertain.

The question cannot be fully answered until we have a more complete assessment of spatial variability within subregions and how representative the existing stations are. However, as proof of concept, the EMP dataset was recently used to assess whether trends in nutrients parameters between 1975 and 1995 were similar or different in different regions of the Delta (ASC, 2016). For most of the nutrient variables, most of the sites had no detectable trends (i.e., no statistically significant trend); however, when long-term trends were detectable, the direction of trend was mostly consistent across the entire region. The exception was ammonia, for which the direction of trend was positive at sites in the Sacramento River, Confluence, and Suisun Bay subregion; negative at South Delta sites; and mixed at Central Delta subregion sites.

ST-1B – How are ambient levels and trends affected by variability in climate, hydrology, and ecology?

— PARTIAL COVERAGE

Robust long-term data sets (water quality, biology, hydrology) generated

by IEP, USGS, and DWR provide a good starting point for these types of analyses. Ongoing data synthesis efforts using advanced statistical models (WRTDS, GAMs, etc.) will reveal any specific data needs for answering questions about key drivers. These data needs will likely be for confounding[1] variables that need to be controlled in the statistical models.

ST-1C – Are there important data gaps associated with particular water bodies within the Delta subregions?

– GOOD COVERAGE

Current data coverage and gaps of existing waterbodies have been reasonably well documented through recent synthesis reports (Novick et al., 2015, Jabusch et al, 2016).

***ST-2 – What is the current status of the Delta ecosystem as influenced by nutrients?* – UNKNOWN**

ST-2A – What is the current ecosystem status of habitat types in different types of Delta waterways, and how are the conditions related to nutrients?

– UNKNOWN

There are a number of biological monitoring programs and special studies in the Delta that could be relevant to this assessment question. Recognized critical data gaps include the lack of monitoring data on the spatial and temporal distribution of both beneficial algal blooms (e.g. diatoms) and harmful algal blooms (e.g., *Microcystis)*. However, the main focus of this report is on the nutrient and nutrient-related monitoring parameters. Addressing gaps in biological assessment programs is beyond the scope of this effort. In the future, the Delta RMP should go through a similar exercise to identify links between nutrient monitoring and biological endpoints.

***SPLP-1 – Which sources, pathways, and processes contribute most to observed levels of nutrients?* – LIMITED OVERALL COVERAGE**

The existing monitoring by USGS and DWR provides insight into the types and magnitudes of nutrient loads from the Sacramento River and San Joaquin River to the Delta, and exports from the Delta to the water intakes of the State and Federal water projects and to Suisun Bay.

SPLP-1A – How have nutrient or nutrient-related source controls and water management actions changed ambient levels of nutrients and nutrient-associated parameters?

– PARTIAL COVERAGE

The existing long-term historical data on ambient concentrations and effluent loads allow the evaluation of major trends in relation to known large-scale changes in source-controls (e.g. elimination of point sources for phosphorus; effects of Regional San's planned upgrade) but not necessarily at the finer temporal and spatial scale needed to evaluate impacts of more specific water management actions or non-point source impacts.

[1] In statistics, a confounding variable "explains away" some or all of the correlation between an independent and a dependent variables.

SPLP-1B – What are the loads from tributaries to the Delta?

– GOOD COVERAGE

The existing monitoring by USGS captures loads in nutrients from the Sacramento and San Joaquin rivers reasonably well under most conditions (with the exception of short-term high intensity events). Loads from the other tributaries – Calaveras, Cosumnes, and Mokelumne Rivers and the Yolo Bypass – are not routinely monitored.

SPLP-1G– What are the types and magnitudes of nutrient exports from the Delta to Suisun Bay and water intakes for the State and Federal Water Projects? **– GOOD COVERAGE**

Sampling frequency and parameters measured at current stations in the Confluence and at the water intakes are sufficient to answer the question.

SPLP-1C – What are the sources and loads of nutrients within the Delta?
SPLP-1D – What role do internal sources play in influencing observed nutrient levels?
SPLP-1E – Which factors in the Delta influence the effects of nutrients?

SPLP-1F– What are the types and sources of nutrient sinks within the Delta?

FM-1– How will ambient water quality conditions respond to potential or planned future source control actions, restoration projects, and water resource management changes?

– VERY LIMITED COVERAGE

A mechanistic biogeochemical-hydrodynamic model is needed to address these questions. Current monitoring is not sufficient, and for the most part not been designed, to provide the necessary data.

5. Critical Data Gaps

Coordination and Integration

There is a need for an up-to-date and maintained inventory of all nutrient monitoring in the Delta. The summary in this report is a good start but limited to the major programs. The Central Valley Monitoring Inventory (www.centralvalleymonitoring.org) was a complete list but has fallen out of date. Not having a complete and searchable inventory is a foundational gap in the program.

The workshop illustrated the utility of a forum for monitoring agencies to coordinate on sampling designs, sampling protocols, interlaboratory measurement consistency and data management, as well as to discuss data needs with modelers. There is no regular forum like this for nutrients in the Delta, which is an organizational gap in the program. Holding an annual workshop with nutrient monitoring agencies, modelers, managers, and researchers would implement one of the recommendations from the Modeling White Paper (Trowbridge et al., 2016).

Status and Trends

Spatial Coverage

There is still much uncertainty around spatial variation of nutrients within and across subregions and what geographic differences in conditions tell us about nutrients and the ecosystem.

Subregions

Sampling by DWR-EMP or any other single monitoring effort does not have the spatial coverage needed to characterize nutrient status and trends in all Delta subregions. The focus in determining additional locations should be on adding missing sentinel sites for specific areas that are currently missing them. The most critical gaps in spatial coverage include

- North Delta, including Cache/Liberty complex, Yolo Bypass, and Barker Slough
- Eastside tributaries
- Large areas of the Central and South Delta
- Georgiana Slough
- Suisun Marsh
- Mainstem Sacramento River and tributaries upstream of the confluence with the Cache/Liberty complex

North Delta: The North Delta is believed to be a dynamic system with strong gradients of nutrients and other biogeochemical constituents, but relatively few historic monitoring data of this system exist. The EMP does currently not have sampling stations in the North Delta. The U.S. Geological Survey (USGS) has installed 5 moored sensors in the North Delta between February 2013 and August 2014.and also conducts monthly sampling of nutrients and chl-a at these stations. Other programs are monitoring nutrients at stations located in the North Delta (e.g. Cache Slough Complex Baseline Study), but data collection is currently not coordinated among different programs, and continuation of these efforts is uncertain. Data that exists to date should be synthesized to a) evaluate what information they provide about spatial variability in this region, b) document the findings of the analyses in the context of the Delta RMP

assessment questions, and c) contribute information to inform future long-term monitoring designs.

Eastside Tributaries: The North-East corridor has been identified as ecologically important but little information exists regarding nutrient concentrations, loadings, and associated phytoplankton and aquatic plant productivity. The EMP does currently not have sampling stations in this subregion. Other programs such as the MWQI are currently conducting short-term monitoring studies in this subregion that may fill some data gaps.

Other under-monitored areas: there is still much uncertainty around spatial variation of nutrients within and across large areas of the Central and South Delta, Georgiana Slough, and Suisun Marsh.

Under-monitored habitats. There are significant data gaps in the coverage of aquatic (vegetated) habitats in margin areas of the Delta, such as sloughs and wetlands around the periphery of the Delta (e.g. North Delta, Eastside Corridor, and Suisun Marsh). The current monitoring is focused on the main water channels.

Ecosystem conditions

Harmful Algal Blooms

There is general agreement that there is an urgent need for monitoring of harmful algal blooms (HABs) and the presence of algal toxins. HABs present a serious threat to ecosystem conditions and human health. HABs would not occur and could not be sustained without abundant nutrients. Even as the role of nutrients as a driver in the system remains unclear, it is recommended that HABs be treated pragmatically as a "nutrient-associated" issue, so that this extremely critical data gap can be filled.

Additional Gaps

Overall, workshop participants felt that focusing status and trends monitoring on nutrients only is too restrictive and that monitoring should also be related to effects.

Alternative monitoring approaches should be evaluated for filling gaps. Some of the routine sampling designs in the Delta are not effective for detecting certain algae blooms. For example, currently used methods for phytoplankton sampling have a high degree of uncertainty for detecting algae that occur in patchy colonies, such as *Microcystis*.

Large-scale synoptic surveys of aquatic habitats (e.g. high-speed mapping) could be useful to identify important aquatic habitats that should be sampled.

Sources, Pathways, Loadings, and Processes

Ultimately, the best tool to answer these assessment questions is a mechanistic water quality-hydrodynamic model. Current models are not ready for this use but are being upgraded to interface with nutrient modules. Gaps in data to calibrate and validate the models will need to be addressed by augmenting existing monitoring programs with additional parameters, stations, and sampling events (increased sampling frequency). Short-term intensive monitoring and special studies will be needed to understand processes, derive rate constants.

Upstream Sources and Loadings

USGS monitoring at Freeport and Vernalis provides data on loads to the Delta from the major tributaries, with the exception of short-term high

intensity events. Less is known about loads from other tributaries such as the Yolo Bypass or Eastside tributaries, which may be significant during some periods, in certain conditions such as above average wet years and high-intensity events.

Upstream Loadings

The existing HF sensor at Freeport may be in jeopardy because of uncertain future funding. It is a potential future data gap. Vernalis lacks a HF nitrate sensor, which is also a big data gap.

Overall, nutrient load estimates for upstream sources are probably biased low, because storm events are not adequately captured. This gap could be filled and prevented from widening through storm sampling to characterize the hydrograph, or by adding/ maintaining nutrient sensors at Freeport, Vernalis, and potentially additional entry points to the Delta such as the Yolo Bypass or Mokelumne River.

Within the Delta

Sources

Nutrient sinks and sources in the Delta, esp. Delta Island drains, are not well understood. Filling this information gap will require a combination of strategic monitoring at strategically selected sentinel sites, intensive studies, research, and modeling. Real-time monitoring – consisting of simultaneous collection of nutrient concentration and flow data – will provide baseline data needed to calculate fluxes and differences in concentrations up- and downstream of potential sources (e.g. major island drains) and sinks (e.g. waterbodies with long residence times functioning as potential transformation hot spots). Additional intensive studies such as strategic high-frequency mapping or grab sample campaigns would be needed to increase spatial coverage during important time periods and to fill in parameters for which there are no routine sensors, such as ammonium and phosphate. Special research studies are needed to establish important transformation processes and calculate transformation rates. More refined estimates of water imports and exports are needed to calculate loads. Finally, combined hydrological and biogeochemical modeling is needed to estimate potentially important sources and sinks at times and locations where there is no monitoring.

Pathways

Developing a better understanding of how waters from different sources flow and mix in the Delta continues to be one the biggest challenges. At many key locations representing Delta in- and outflows, hydrologic sources and source mixing have not been fully evaluated under a wide range of flow conditions. Hydrodynamic models are available that can be applied to fill this gap.

The lack of sediment sampling hinders the evaluation of the accumulation and fate of nutrients within the Delta. In some areas of the Delta, the sediment is believed to be a source of nutrients.

Loadings

Good information exists on point source loadings within the Delta, but non-point source loads are poorly understood. Land use export models combined with targeted monitoring of fluxes at key locations are needed to characterize these important sources of nutrients.

Processes

Critical information gaps that limit our understanding of important large-scale

processes and fluxes, and thus limit model development, include:

- Lack of data for nutrient model constituents at some model inflow boundaries, such as Lisbon/Yolo, Cosumnes, Mokelumne, and Calaveras.
- Rates and controls on nutrient uptake and transformation (including mineralization) in the aquatic environment, and especially at the water/sediment interface and in wetlands.
- Role of organic material in Delta in moving nutrients through the system
- Baseline data on the microbial foodweb and its role in nutrient cycling
- Conceptual model gaps preventing the closure of nitrogen budgets, including the role of denitrification and nitrous oxide production
- Biomass of submerged and floating aquatic vegetation (SAV/FAV). This information is a prerequisite to understanding the role of SAV/FAV in nutrient cycling
- Lack of measurements at depth, which are required for model calibrations and improved load estimates
- Lack of isotope data for nitrogen and other parameters to illuminate these processes and others.
- Stoichiometry of primary producers. Stoichiometric data would provide insights in nutrient requirements of primary producers.

DSM2 is the primary model in use now for simulating water quality conditions in the Delta. DWR is conducting a special study to collect additional data to calibrate and validate a nutrient module for DSM2. Even with this study, there are still more data gaps for nutrient modeling with DSM2-QUAL, which include

- Temporal availability of measurement data limits Delta-wide model runs to a monthly time steps, and therefore, outputs. Processes occurring at shorter time scales cannot be calibrated. Weekly or daily time steps may be necessary to adequately address some nutrient-related questions
- Spatial availability of data limits quality of model calibration regionally
- Lack of individual constituent measurements limits use of model for some constituents

There are plans for adding nutrient modules to other existing hydrodynamic models of the Delta (SCHISM, CASCaDE). These models are more complex than DSM2. Therefore, more data and special studies will be needed to set model boundary conditions and to calibrate these models.

Forecasting Scenarios

A linked physical-biogeochemical model is needed to generate predictions under scenarios of possible changes and management actions in the Delta. Current models are not ready for this use, in part because specific data are missing to validate rate constants for uptake and loss of nutrients. Current models also cannot evaluate the effects of nutrients on phytoplankton production.

6. Approaches for Addressing Critical Monitoring and Analysis Needs

Feedback received in interviews with representatives of Delta monitoring and resource management programs suggests that the current monitoring network could be integrated and optimized to better address Status and Trends questions for nutrients and to provide baseline data that help answer questions concerning Sources, Pathways, Loadings, and Processes.

Possible approaches toward achieving this goal will be outlined generally in this section. The approaches can be implemented through a mixture of short-term and long-term actions. Some of the options are obvious "no regrets" actions. Others require significant resources and institutional support.

Approaches for Better Coordination and Integration of Existing Monitoring Efforts

Policy-Level Coordination

There are opportunities to fill data gaps through better integration of existing data collection and evaluation efforts (by DWR, USGS, Delta RMP, and others). Alignment of program objectives and permit requirements would facilitate alignment of monitoring designs (e.g., coordinate monitoring requirements for renewed State Board Water Right Decisions, Delta Science Program directed action goals, Delta Nutrient Research Plan study questions, and Delta RMP assessment questions).

Technical Coordination

Even if program objectives cannot be perfectly aligned, actions could be taken to make the data collected by the different programs more accessible and more easily shared such as:

- Foster sensor network interoperability between USGS and DWR programs.
- Integrate and synchronize grab sample collection by different programs (EMP, MWQI, NRCO, USGS, Delta RMP)
- Interlab comparisons and coordination of QA programs. Sensors are the highest priority – because of the near-complete absence of such efforts to-date and associated missed opportunities for data integration. The second tier consists of comparisons of analytical methods for discrete samples (e.g., NH4 at low levels, organic-N, organic-P) and of associated sampling and handling procedures.

Recommended approaches for achieving better coordination also include the use of shared tools to facilitate such efforts. Existing tools include

- Central Valley Monitoring Directory as an online resource for information on who is monitoring what and where
- Data visualization tools, such as the Estuary Portal, for coordinating data sharing and assessment

This approach would require additional investment to update the inventory and upgrading and adapting data visualization and mapping tools so that

they specifically meet the identified needs.

Finally, an annual workshop and smaller workgroups would be good approaches for improving coordination between agencies and for tackling issues such as laboratory intercalibration.

Data Analysis and Synthesis

The Delta RMP has completed three synthesis reports to date: one on high-frequency sensor monitoring and two on grab sample monitoring (the latter reports were completed with in-kind funding from DWR[2] and DSP[3]). The reports have used a limited portion of the data available to answer specific questions about monitoring design optimization, which fed directly into this report. Some of the recommendations from the first reports have already been implemented by DWR, which is a significant benefit to the Delta RMP. Additional analysis of data is likely to yield more insights.

Monitoring data should be synthesized and translated into useful information on an ongoing basis. Moreover, additional data collection should only proceed if there is also enough funding for data analysis, synthesis, and interpretation. For example, a number of short-term studies are currently collecting nutrient data in the North Delta, filling information gaps. These data should be synthesized and assessed against Delta RMP assessment questions to evaluate new information gained and remaining monitoring gaps.

The scope of additional synthesis tasks should be carefully planned by the Nutrient Subcommittee to ensure that it builds off of previous work and clearly addresses Delta RMP assessment questions. In addition, coordination with other agencies who prepare data reports could yield benefits if their reports could be modified to meet Delta RMP needs.

Approaches for Addressing Data Gaps Relative to Understanding Status and Trends

Increasing Spatial Coverage

Existing long-term monitoring programs do not cover all regions of the Delta. Additional long-term monitoring stations are needed in the following regions:

- North Delta, including Cache/Liberty complex, Liberty island, Yolo Bypass, and Barker Slough
- Eastside tributaries
- Large areas of the Central and South Delta
- Georgiana Slough
- Suisun Marsh

Improving and Increasing Temporal Coverage

Timing of Sampling

[2] Novick E, Holleman H, Jabusch T, Sun J, Trowbridge P, and Senn D, Guerin M, Kendall C, Young M, Peek S. 2015. Characterizing and quantifying nutrient sources, sinks and transformations in the Delta: synthesis, modeling, and recommendations for monitoring. San Francisco Estuary Institute, Richmond, CA. http://sfbaynutrients.sfei.org/sites/default/files/Main manuscript.pdf

[3] Jabusch T, Bresnahan P, Trowbridge P, Wong A, Salomon M, and Senn D. 2015. Summary and Evaluation of Delta Subregions for Nutrient Monitoring and Assessment. San Francisco Estuary Institute, Richmond, CA. http://www.sfei.org/sites/default/files/biblio_files/MainReport-DSP_2016-06-30.pdf

There is a need to improve attention to flow conditions during sample collection (where in the *tide* as well as relative to storm events, reservoir releases, water exports, barriers, etc.).

High-Frequency Sensor Technology Development

Ammonium: At present, there are no commercially available sensors for in situ measurement of ammonium, although the USGS currently has two prototype ammonium sensors operating periodically in the Delta and is exploring options for a sensor that could be incorporated into boat-based mapping campaigns.

Completing the full development of existing prototype ammonium sensors would enable routine high frequency monitoring of ammonium, allowing baseline monitoring needed to understand ammonium dynamics in the Delta.

HABs: A long-term continuous monitoring network of adequate spatial density, equipped with optimized phycocyanin sensors, has the potential to serve as an observation and warning system for cyanoHABs. Current instruments generally report low or no presence of blue-green algae, because they miss large algae cells and *Microcystis* aggregates, which are responsible for most occurring blooms.

Monitoring Ecosystem Conditions

Collecting Data on Microcystis/HABs

Add collection of net phytoplankton sampling, analysis of toxins in the water column and/or in clams, and/or molecular detection of toxigenic strains to existing routine monitoring.

Exploring Alternative Monitoring Designs for Evaluating Status and Trends

Alternatives to traditional sampling and analysis methods to fill-in the gaps should continue to be explored. For example, the feasibility of a randomized probabilistic design for assessing nutrient conditions across the Delta or specific habitats in the Delta should be evaluated to determine cost-effectiveness.

Approaches for Addressing Data Gaps Relative to Understanding Sources, Pathways, Loadings, and Processes

Collecting Data Needed for Modeling

Add Missing Nutrient Parameters to Existing Monitoring Locations

In addition to adding new stations to improve Status and Trends assessment, missing nutrient parameters are needed at some of the existing monitoring locations representing model boundary conditions (currently monitored by MWQI DMS2 Nutrient Study, USGS, NCRO).

Ideally, monitoring should occur at all model boundaries (these locations are fairly standard across Delta models). Discrete sampling should be co-located with HF sensors, to collect additional parameters for which there is no sensor. Additional high frequency sampling should be timed for when the rates of nutrient dynamics are high or boundary conditions (inflows AND exports) are changing rapidly.

Baseline Data Collection With High-Frequency Sensor Network

An extended high-frequency nutrient sensor network of strategically placed continuous monitoring stations would provide additional critical baseline monitoring data needed for models.

These data will also help improve trend detection and loading estimates. Sensors should include in situ high frequency nitrate analyzers and may also include PO4 and NH4 analyzers.

Bergamaschi et al. (in review) have produced a nutrients sensor synthesis report for the Delta RMP. This report includes examples for nutrient sensor network designs to help address Delta RMP assessment questions.

Example 1: Minimal network focused on Fluxes and Loads. Core network of three stations that include:

1. Sacramento River @ Walnut Grove (existing)
2. Cache Slough @ Ryer Island (existing)
3. San Joaquin River downstream of the Stockton wastewater treatment plant

This core network would capture temporal variability in fluxes and loads from the Sacramento River watershed including the Sacramento urban area and Regional wastewater treatment plant; from the San Joaquin River including the Stockton wastewater treatment plant, and from the North Delta.

Network 2: Internal sources, processes and rates. Network of six new stations that may include:

1. Sacramento River @ Rio Vista
2. San Joaquin River @ Jersey Point
3. Old River @ Frank's Tract
4. Old River nr Byron
5. Middle River nr Holt
6. Middle River @ Middle River

The goal of this network would be to document internal nutrient loads in the Central Delta including loading from island drains and wetlands, and evaluate the extent to which nutrients are attenuated through interaction with wetlands and submerged islands. Includes monitoring of nutrient concentrations of water bound for export. Presumes external loadings to the Delta are adequately constrained by other stations and/or programs.

Special studies for calibrating models

Special studies to understand processes, establish rate constants, and calibrate models are also needed. The focus of the studies will depend on the processes and parameters in the model, and may include

- Tidal exchange of nutrients by marshes
- Nutrient dynamics at the sediment/water interface (role of denitrification)

High-Frequency Mapping

Boat-based high-frequency mapping provides the quickest and easiest approach for collecting data that assist in model calibration and validation. HF mapping is a cost-effective approach that allows to

- Characterize areas that are currently not represented in the fixed station design (e.g., back sloughs)
- Help resolve gradients in nutrient concentrations and other parameters, and
- Identify nutrient sources and hot spots of nutrient consumption or transformation.

Process and Fate Studies

Stable Isotopes: Stable isotope analysis is a promising analytical tool for

evaluating sources, transport, uptake, and transformation of nutrients in various ecosystem components. Stable isotope analyses are a potential tool to study changes in nutrient processing before, during, and after the implementation of the EchoWater Project.

7. Options for "No Regrets" Nutrient Monitoring for the Delta RMP

The operational definition of **"no regrets" activities** for this report are actions that:

- Fill a clear gap in the networks of fixed monitoring stations,
- Provide necessary data for models,
- Meet any other obvious baseline monitoring and analysis needs
- Follow a flexible and adaptable design that can inform future nutrient questions.

The purpose of this document is to outline "no regrets" nutrient monitoring options for the Delta RMP. The previous section outlined some broad approaches to filling data and information gaps relative to the Delta RMP's assessment questions. This section highlights options for a few concrete tasks that could be implemented by the RMP to start to address these gaps without risk of wasting resources. The table on page 35 shows the data gap that each option would address relative to answering Delta RMP assessment questions.

The estimated costs for each option are for planning purposes only. These estimates are rough and will need to be confirmed if the Delta RMP decides to implement any of these options.

Not all of these options meet the operational definition for "no regrets" *per se.* Some recommendations can be considered foundational activities that should occur so that "no regrets" activities can be implemented.

1. Coordination and Integration (Foundational Activities)

Option 1a. Coordination Workshops – FOUNDATIONAL ACTIVITY

- Hold regular workshops and meetings among modelers and monitoring agencies to coordinate data collection, understand data needs for models, evaluate monitoring program efficacy in relation to program objectives, and optimize monitoring designs. These workshops would each result in a brief report with a list of recommendations for new nutrient monitoring locations and timing, and plans for increased coordination among the monitoring agencies.
- Hold workshops on laboratory quality assurance/intercalibration and field/lab SOPs. The goal is to promote consistency between the various programs that conduct discrete grab sample and continuous monitoring. Workshop participants considered the continuous sensor network interoperability as the most critical gap. A workshop would address QAQC, data management, and data access and synthesis, and could set the stage for inter-group comparisons.

Estimated cost: $15-50k per workshop

***Option 1b. Coordination and Integration Tools* — FOUNDATIONAL ACTIVITY**

- Update the inventory of nutrient monitoring programs with a more detailed summary of what data are collected: where, what (e.g., NO3, NO2, NH4, DON, TDN, TN, TP etc.), when (start date-end date, approx. frequency). This would allow for a thorough identification of data gaps and places where additional sampling or simply additional analyses could be "piggybacked". This activity could also help identify ways the current resources could be more efficiently and effectively applied.
- *Extended activity I:* Update and maintain an online geodatabase of who monitors what, where, and when, including cruise tracks. The inventory should be able to keep track of the history of changes in each program and should allow comparison of sample collection, instrument calibration, analysis methods, and QA/QC results. Programs that were not included in this report should be added (e.g., ILRP, stormwater, pre- and post-restoration monitoring).
- *Extended activity II:* Develop or customize available data visualization and integration tools to readily compile all nutrient data in the Delta.
- *Extended activity III:* Develop tools for reporting on nutrient trends in the Delta.

Estimated cost: $30-250k

2. Status and Trends

***Option 2a. "Piggybacking"*— FILLS SPATIAL, TEMPORAL, AND PARAMETER GAPS**

"Piggybacking" involves the leveraging of existing programs to ensure critical data are collected. It involves the addition of new stations, parameters, and increased sampling frequency *to existing routine monitoring programs*. It would make sense to "piggyback" onto the EMP to the extent that it is feasible and practical, because the EMP has been collecting monthly data for more than 40 years with consistent timing relative to tides, and has been measuring a broad suite of nutrient and nutrient-associated variables.

Based on the current inventory of monitoring programs, the spatial, temporal, and parameter data gaps that could be filled by "piggybacking" activities include

- Resume monitoring at discontinued EMP stations and/or add new stations (1-4 total) to existing routine monitoring in under-monitored areas, to increase the density and representativeness of spatial coverage. Potential locations:
  - Central Delta: Little Potato Slough, Middle River at Union Point, San Joaquin River at Prisoner's Point (existing DWR-EMP chlorophyll sensor), and Staten Island
  - Eastside: potential locations include Mokelumne River at New Hope Road and Delta Cross-Channel
  - North Delta: opportunities for co-locating discrete sampling sites with the existing USGS sensor stations include Cache Slough (CCH),

Deep Water Shipping Channel (DWS), Liberty Cut (LCT), Liberty Island (LIB), and Toe Drain North of Stair Steps (TOE).

- Sacramento River: potential locations include Freeport (USGS sensor and sampling station) and Walnut Grove (USGS sensor WGA)
- South Delta: potential locations include San Joaquin River at Mossdale (existing DWR-EMP chlorophyll sensor) and Old River near Tracy.

Piggybacking may also extend to high-intensity sampling during high-flow events. Additional discrete sampling that targets large storms, to improve calculation of loads from the Sacramento and San Joaquin Rivers, and potentially additional tributaries, such as the Yolo Bypass and eastside tributaries, during high discharge events. The potential activity is to conduct sampling along the hydrograph to fully characterize various nutrient types. Field crews that are already collecting water samples during storm events for other constituents would collect the samples.

Planning to complete before deciding how to augment the existing monitoring network includes:

- Complete the inventory. The inventory of existing nutrient monitoring should be updated (see Option 1b above) to provide a comprehensive view of existing nutrient monitoring in the Delta.
- Agree on a list of critical parameters. The broad suite of nutrient and nutrient-associated parameters that are needed at key locations should be identified. Needed measurements include additional drivers of biological activity, such as temperature and turbidity.
- Determine the optimal frequency of monitoring for each parameter. Increase sampling frequency at ecologically important locations and times. For example, more frequent sampling during critical times will provide more useful data for monitoring algal blooms. More monitoring is recommended in the spring and fall. For high frequency measurements, moored sensors could be deployed at fixed stations but could also be considered for stations that get moved around (e.g. shipside HF sensor for salinity-based stations).
- Develop relationships between chlorophyll *a* and algal biomass.

Assessment questions: ***ST1, ST1A****.*
Estimated cost: $10-150k/yr

Option 2b. HAB Sampling – Fills Parameter Gaps

Fill a critical ecosystem condition indicator gap by adding HAB monitoring. The initial focus of this monitoring would be on addressing public health and ecosystem concerns, and gaining a better understanding of bloom dynamics and their spatial and temporal extent. HAB sampling would follow a targeted design that would track the development and occurrence of blooms and would be triggered when certain conditions (e.g. visual inspection) suggest a bloom is forming. Measurements may include sampling and filtration of water samples for toxin analysis, net phytoplankton collection for microscopic analysis, or molecular techniques for detecting the presence of toxic algal strains. HAB sampling will need to encompass a broad range of

additional parameters, including nutrient measurements and other indicators of biological activity, such as flow, temperature, and EC.

Recommended foundational activities include

- *Prior to implementation:* establish a protocol for a tiered monitoring response to HABs. SWAMP is currently developing a sampling and laboratory analysis guide that will include Standard Operating Procedures for field collection and laboratory methods, tiered approach to sampling and analysis, and performance based quality assurance. This document is expected to provide guidance for decisions about sampling sites and the timing of sample collection.

Assessment questions: ST1, ST1A, ***ST2, ST2A****. Estimated cost: $100-200k/yr*

Option 2c. Nutrient Data Analysis and Reporting – INFORMS FUTURE DESIGN

This option consists of continued synthesis and integration of existing data. The synthesis reports completed so far have focused on two datasets (EMP and USGS high-frequency sensor networks) and on questions about optimizing monitoring designs (Novick et al. 2015, Bergamaschi et al., in press, Jabusch et al. 2016, see Appendix C Bibliography for full references and links). Additional datasets and assessment questions could be evaluated, such as questions about the effects of nutrients on the ecosystem.

The first step of additional synthesis work would be for the Nutrient Subcommittee to provide clear direction on the Delta RMP assessment questions to be answered, how the scope of work differs from the previous reports, and whether other agencies (e.g. DWR, USGS) could modify their reports to answer the questions (e.g. include a specific analysis, table, or figure). A biannual report presenting the synthesized information could be produced, which provides the current state of knowledge in answering the Delta RMP assessment questions related to nutrient trends and effects.

Assessment questions: ***ST1, ST1B, ST1C****, ST2, ST2A, SPLP1, SPLP1C. Estimated cost: $50k project or $500k over 3 years (2 high-level FTEs, multi-year effort).*

Option 2d. Nutrient Data Synthesis for Specific Area or Habitat Type – INFORMS FUTURE DESIGN

Data analysis should also extend to more specific information gaps, such as focused analyses of under-monitored subregion for which data exist but have not been synthesized and assessed against the Delta RMP assessment questions. The focus could be on under-monitored subregions, such as the North Delta, and/or habitat types, such as low-flow channels.

At the workshop, participants specifically discussed the idea of a North Delta Synthesis. The North Delta is considered an under-monitored geographic area where important biogeochemical processes occur. With oversight by the Nutrient Subcommittee, all existing data in this region (including data from HF sensor monitoring, MWQI data collection efforts, and the SDSC special study) could be pulled together and evaluated relative to the Delta RMP assessment questions. Such an analyses would also inform a regional monitoring design and reveal remaining uncertainties and needs. Some of these data will be summarized in technical

reports (MWQI und USGS studies), others may be published in scientific journals (SDSC study and USGS research). The final product would be a synthesis of findings from these sources – to the extent that they are available - and additional statistical analyses of the data. The analysis could also include data from the Sacramento River, to evaluate differences in biogeochemical processes. Presentation could be in a standalone technical report or as a section in a larger report describing the overall nutrient trends in the Delta.

However, analyses of other subregions or habitat types might be considered equally important. For example, there are major problems with HABs, macrophytes, and dissolved oxygen (DO) in the South Delta. Thus, a certain amount of planning must still be completed before decisions are made about scope and goals of the syntheses.

Assessment questions: ***ST1, ST1B, ST1C, ST2, ST2A, SPLP1, SPLP1C.*** *Estimated cost: $50-100k (Data compilation/statistical analyses/technical report).*

3. Sources, Pathways, Loadings, and Processes

Option 3a. "Piggybacking" Missing Model Parameters – DATA FOR MODELS

Augment suite of parameters analyzed on discrete samples (to inform modeling) to existing stations where they are not collected. *Assessment questions: ST1, ST1A,* ***SPLP1, SPLP1B, SPLP1C, SPLP1F, SPLP1G.*** *Estimated cost: $15-60k/yr*

Option 3b. High Frequency (HF) Mapping – DATA FOR MODELS

Use HF data collection cruises to map nutrients and other parameters in subregions to understand nutrient transformations and potential internal loading in under-sampled Delta locations. The recommended monitoring campaign would be designed to characterize seasonal changes in flow and water quality. It would consist of 2-4 high-speed boat HF data collection cruises (~4 days each) to characterize spatial variability and characterize biogeochemical gradients in under-monitored subareas (e.g. South and North Delta) and/or waterbody types (e.g. back sloughs) under different flow scenarios. (E.g. 2 winter sampling events and 2 summer sampling event in the North/Northeast, Central Delta/ Sacramento River subregions and/or the South Delta. Measurements include: NO3, NH4, PO4, DO, chl-a, and BGA pigments. *Assessment questions: ST1, ST1A, ST1B, ST2, ST2A,* ***SPLP1, SPLP1C, SPLP1D, SPLPF.*** *Estimated cost: $100K-$170K (Depending on # of water cruises and locations; scalable)*

Additional Options

The following additional options meet the "no regrets" definition to a large degree, but not entirely. They were identified as "next best" options for potentially useful projects. All of them have some downside risk. These options have been included in the report to provide the Delta RMP committees with a broader perspective of options to consider.

- **Sustaining Existing HF Sensor Sites With Uncertain Future Funding.** In some circumstances, it may be an appropriate task for the Delta RMP to fund the continuation of HF monitoring and/or other stations that provide critically needed information and would otherwise be lost due to a lack of funding. For example, there is a possibility that the HF nutrient sensor network might become unfunded in the future. However, more in line with the Delta RMP's stated mission would be to leverage the existing network through improved coordination, integration and synthesis of data that are being collected, and additional monitoring that fills critical gaps that have yet to be filled. That is, adding capacity and bringing in additional resources rather than replacing the funding sources for existing ones. This option should only be considered if all other options have been exhausted and no other funding source can be identified.
- **Nutrient concentrations and fluxes in the upper Sacramento River (upstream of the legal Delta).** Sample nutrient concentrations at upper Sacramento River locations, such as Knight's Landing, Verona, and Discovery Park, to better characterize nutrient concentrations and fluxes in the upper Sacramento River (upstream of the legal Delta). This activity would further reduce uncertainty around variability in constituent concentrations and estimates of sources and loadings entering from the Sacramento River watershed. However, it is outside of the geographic area the Delta RMP is focusing on and there are a number of seemingly critical data gaps (from the RMP's perspective) inside the Delta that remain unfilled.
- **Sediment flux.** Nutrient fluxes in sediment remain a critical data gap, and there is a dearth of sediment nutrient data. The potential activity would be design and implement a pilot study for a seasonal sampling program that would create a baseline for characterizing nutrient fluxes at the sediment/water interface. However, this monitoring would provide its full value only if combined with controlled research experiments and modeling. Rates of exchange and transformation in various types of Delta sediments are needed to simulate a range of environmental conditions and management scenarios.
- **Nutrient loadings from (or uptake by) Delta wetlands** are a significant data gap. One potential approach for filling this gap would be a pilot study by strategically collecting nutrient data at the mouth of a selected

tidal marsh sloughs or diked wetlands outfall. Such monitoring would be most useful if performed before and after a wetland restoration project. As for sediments, a monitoring study would provide its full information value only in combination with experimental research and modeling, which would be required to establish biogeochemical processes and rates of exchange and transformation.

Table 3. Summary of options for "No Regrets" Nutrient Monitoring for the Delta RMP

Project	Gap	Scope	Assessment Questions	Cost/year
1. Coordination and Integration				
1a. Coordination workshops	Informs future design	Coordinate, prepare, and facilitate workshop; write workshop summary or report		$15-50K
1b. Coordination and Integration Tools	Informs future design	Update and maintain a master list of who monitors what, where, and when. Include a cruise track. Inventory should be able to keep track of the history of changes in each program. Lower end: basic Wiki or Google site (similar to TAC site) with compilation of tables. High end: fully upgraded mapping and data entry tools for monitoring directory; staff time to customize and populate Estuary Portal with desired metadata, data, functions, and web services (data visualization and integration tools) that may be missing. Report on nutrient trends in the Delta.		$30-$250K
			Total – Coordination and Integration	*$45-$300K*
2. Status and Trends				
2a. "Piggybacking"	Fills spatial, temporal, or parameter gaps	Lower end: analysis of broad suite of nutrient- and nutrient-associated parameters by DWR Bryte Laboratory (12-48 samples): e.g. monthly sample collection at new stations (1-4 total) added to existing routine monitoring in under-monitored areas. High end: four new superstations (4 HF sensors combined with monthly grab sampling)	**ST1, ST1A**	$10-150K
2b. HAB Sampling	Fills parameter gaps	Targeted sampling of HABs. Options include sampling and filtration of water samples toxin analysis, net phytoplankton collection for microscopic analysis, or molecular techniques for detecting the presence of toxic algal strains. Broad range of additional measurements (nutrients and measurements for other drivers of biological activity). (10-20 sampling events/10-20 stations).	ST1, ST1A	$100-$200K
2c. Nutrient Data Analysis and Reporting	Informs future design	Data compilation, statistical analyses/trend analyses, evaluation of data against assessment questions/data interpretation, preparation of technical report.	**ST1, ST1B, ST1C**, ST2, ST2A, SPLP1, SPLP1C	$50-500K

Project	Gap	Scope	Assessment Questions	Cost/year
2d. Data Analysis for Specific Area or Habitat Type	Informs future design	Data compilation, statistical analyses/trend analyses, evaluation of data against assessment questions/data interpretation, preparation of technical report	**ST1, ST1B, ST1C**, ST2, ST2A, SPLP1, SPLP1C	$50-100K
			Total – Status and Trends	*$210-$950K*
3. Sources, Pathways, Loadings, and Processes				
3a. "Piggybacking" Missing Model Parameters	Data for models	Broad suite of nutrient- and nutrient related parameters (~12-44 samples: 1-4 stations x 12 events)	ST1, ST1A, **SPLP1, SPLP1B, SPLP1C, SPLP1F, SPLP1G**	$15-60K
3b. HF Mapping Studies	Data for models	Installation of nitrate sensor	ST1, ST1B, **SPLP1, SPLP1B**	$100-170K
			Total – Sources, Pathways, Loadings, and Processes	*$115-$230K*
			Total – All Projects	***$370-1,480K***

Table 4. Estimated coverage of Delta RMP monitoring questions by existing monitoring and significance of proposed activities for addressing them. This table does not include Coordination and Integration activities.

	Assessment Questions	Existing monitoring	2a. Piggyback	2b. HAB sampling	2c. Nutrient data analysis and reporting	2d. Data synthesis for specific area or habitat type	3a. Piggyback model parameters	3b. HF mapping studies
ST1	**How do concentrations of nutrients (and nutrient-associated variables) vary spatially and temporally?**							
ST1A	Are trends similar or different across subregions of the Delta?							
ST1B	How are ambient levels and trends affected by variability in climate, hydrology, and ecology?							
ST1C	Are there important data gaps associated with particular water bodies within the Delta subregions?							

Legend

Pie charts indicate the extent to which current programs provide data coverage for addressing the question.

Stars signify the degree to which the "no regrets" activity would improve data coverage for addressing the assessment question. Open stars relate to assessment questions that are not considered an initial priority in the Delta RMP Monitoring Design.

ST2	**What is the current status of the Delta ecosystem as influenced by nutrients?**							
ST2A	What is the current ecosystem status of habitat types in different types of Delta waterways, and how are the conditions related to nutrients?							
SPLP1	**Which sources, pathways, and processes contribute most to observed levels of nutrients?**							
SPLP1A	How have nutrient or nutrient-related source controls and water management actions changed ambient levels of nutrients and nutrient-associated parameters?							
SPLP1B	What are the loads from tributaries to the Delta?							
SPLP1C	What are the sources and loads of nutrients within the Delta?							

SPLP1D	What role do internal sources play in influencing observed nutrient levels?							
SPLP1E	Which factors in the Delta influence the effects of nutrients?							
SPLP1F	What are the types and sources of nutrient sinks within the Delta?							
SPLP1G	What are the types and magnitudes of nutrient exports from the Delta to Suisun Bay and water intakes for the State and Federal Water Projects?							
FM1	How will ambient water quality conditions respond to potential or planned future source control actions, restoration projects, and water resource management changes?							

Appendix A: Descriptions of Existing Nutrient Monitoring Activities in the Delta

List of Programs

1. California Department of Water Resources (DWR) – Environmental Monitoring Program (EMP)
2. DWR – Municipal Water Quality Investigations (MWQI)
3. DWR – North Central Region Office (NRCO) Water Quality Evaluations
4. DWR – Special Studies Research Program
5. U.S. Bureau of Reclamation – Sacramento Deepwater Ship Channel
6. U.S. Geological Survey (USGS) – National Water Quality Assessment (NAWQA) Program
7. USGS – High-Frequency (HF) Nutrient Monitoring Network
8. Regional San - Monitoring of Sacramento River Receiving Waters and Upstream Waters
9. Stockton RWCF – Monitoring of Receiving Waters

1. California Department of Water Resources - Environmental Monitoring Program (EMP)

Summary:

How and to what extent does it address Delta RMP assessment questions?

The EMP has been collecting nutrient data as part of larger monitoring program since 1975. Due to the existence of the 40-year data record generated by the EMP, regional long-term trends are reasonably well understood. The EMP can be considered as the core data collection effort for addressing the Delta RMP Status & Trends (S&T) nutrient assessment questions. Data from EMP stations are also critical for Delta RMP Sources, Pathways, and Loadings questions such as calculating nutrient exports from the Delta from water withdrawals and Delta outflow.

Opportunities

The EMP operates under the auspices of the Interagency Ecological Program (IEP), which has a strong interest in the Delta RMP S&T nutrient assessment questions and in collaborating with the Delta RMP on nutrient monitoring. Therefore, the EMP invites feedback for how the program can be optimized to address the Delta RMP nutrient assessment question ST-1 ("How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally?").

The IEP community is particularly interested in the effects of changes in nutrients on phytoplankton, zooplankton, and other components of the estuarine foodweb. Therefore, there is particular interest, as a next step, in collaborating to address question S&T2 ("What is the current status of the Delta ecosystem as influenced by nutrients?") and looking at ways for optimizing nutrient monitoring in concert with improving monitoring of biology and other ecosystem aspects.

Coordination between the Delta RMP and the IEP Science Management Team provides an opportunity for aligning program activities to achieve mutual objectives for ecosystem monitoring and assessment.

Constraints

The EMP needs to operate within its mandate of determining compliance with D-1641 water quality standards.

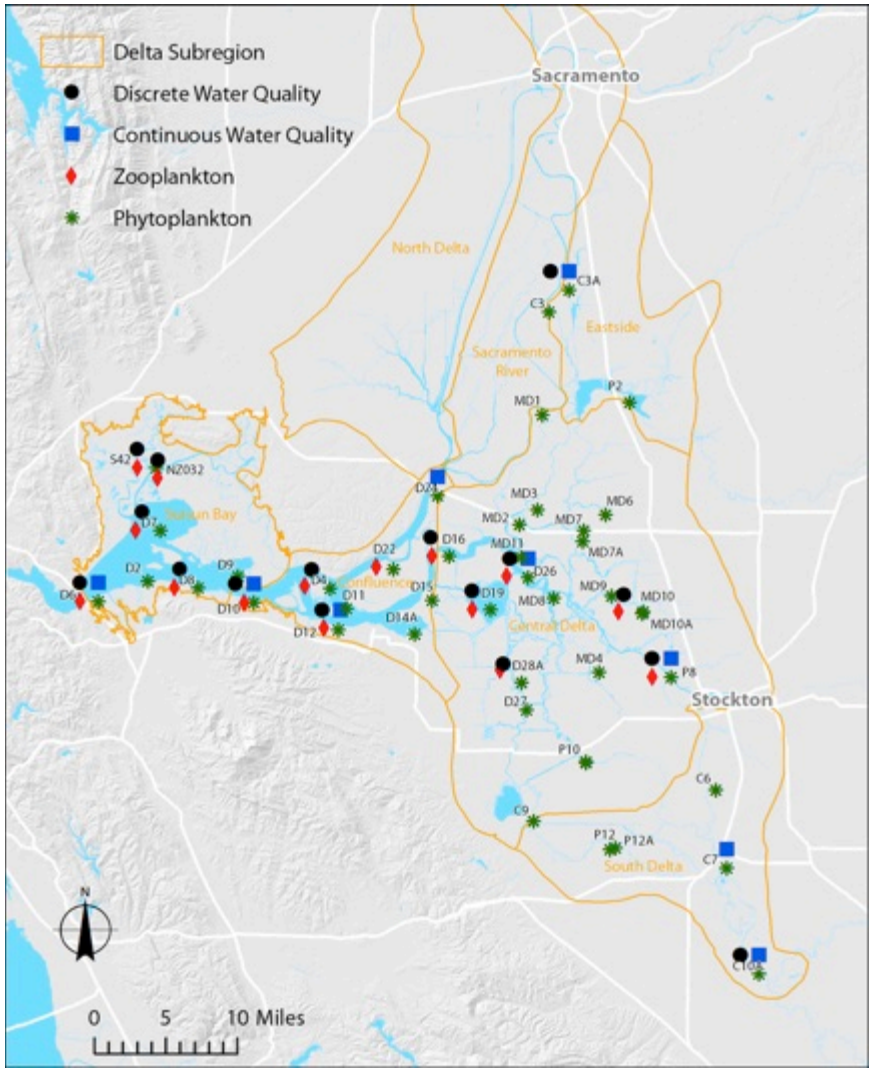
Program Description: DWR-EMP

Related Goals and Activities: Has been collecting nutrient data at sites in the Sacramento-San Joaquin Delta and Suisun Bay since 1975.

EMP's Monitoring of Nutrients and Nutrient-associated Variables

Program Element	Start	Sampling frequency	Nutrients monitored	Nutrient-associated variables monitored
Discrete Water Quality	1975	Monthly Grab sampling by boat	Ammonia, Kjeldahl nitrogen, nitrite + nitrate, organic nitrogen, ortho-phosphate, phosphorus, silica	Chlorophyll a, phaeophytin a; general water quality and standard minerals (calcium, EC, TDS, TSS, VSS); DOC, TOC; field measurements (DO, EC, fluorescence, pH, temperature, turbidity, Secchi depth)
Continuous Water Quality	1971	Every 15 minutes	None	Chlorophyll, DO, EC, pH, temperature, turbidity
Phytoplankton	1975	Monthly Sample collection with submersible pump by boat	None	Phytoplankton abundance and taxonomic composition
Zooplankton	1968	Monthly Sample collection with a mysid net, a Clarke-Bumpus net (targets adult and juvenile copepods, and cladocerans), and a pump (targets adult and juvenile cyclopoid copepods of the genera *Limnoithona* and *Oithona*, copepod nauplii, and rotifers) by boat	None	Zooplankton abundance and taxonomic composition

Sampling Locations:



List of Monitoring Stations

Station Code	Location	Subregion	Program Element	Co-located with Flow
C3A	Sacramento River @ Hood	Sacramento River	Discrete Water Quality, Real-time Data, Phytoplankton	X
C7A	San Joaquin River @ Mossdale	Central Delta	Real-time Data	X
D16	San Joaquin River @ Twitchell Island	Central Delta	Discrete Water Quality	
D16A	San Joaquin River near Twitchell Island	Central Delta	Real-time Data	
D19/D19A	Frank's Tract	Central Delta	Discrete Water Quality, Real-time Data, Phytoplankton	
D28A	Old River @ Rancho Del Rio	Central Delta	Discrete Water Quality, Phytoplankton	X
D29	San Joaquin River at Prisoners Point	Central Delta	Real-time Data	X
MD10A	Disappointment Slough @ Bishop Cut	Central Delta	Discrete Water Quality, Phytoplankton	
P8	San Joaquin River @ Buckley Cove	Central Delta	Discrete Water Quality, Phytoplankton	
P8A	San Joaquin River @ Rough and Ready Island	Central Delta	Continuous Water Quality	X
D4	Sacramento River above Point Sacramento	Confluence	Discrete Water Quality, Phytoplankton	
D10	Sacramento River @ Chipps Island	Confluence	Discrete Water Quality	
D10A	Sacramento River @ Mallard Island	Confluence	Continuous Water Quality	X
D11A	Sacramento River Near Sherman Lake	Confluence	Continuous Water Quality	
D12/D12A	San Joaquin River @ Antioch Ship Channel	Confluence	Discrete Water Quality, Continuous Water Quality	
D22	Sacramento River @ Emmaton	Confluence	Discrete Water Quality	
D24A	Sacramento River @ Rio Vista	Confluence	Continuous Water Quality	X
D6/D6A	Martinez	Suisun Bay	Discrete Water Quality, Phytoplankton, Continuous Water Quality	
D7/D7A	Grizzly Bay	Suisun Bay	Discrete Water Quality, Phytoplankton, Continuous Water Quality	
D8	Suisun Bay off Middle Point nr. Nichols	Suisun Bay	Discrete Water Quality, Phytoplankton	

Station Code	Location	Subregion	Program Element	Co-located with Flow
D8A	Suisun Cutoff near Ryer Island	Suisun Bay	Continuous Water Quality	
D9A	Honker Bay	Suisun Bay	Continuous Water Quality	
NZ032	Montezuma Slough, 2nd bend from mouth	Suisun Bay	Discrete Water Quality*	
NZS42	Suisun Slough @ Volanti Slough	Suisun Bay	Discrete Water Quality*	
C10A	San Joaquin River near Vernalis @ SJR Club	South Delta	Discrete Water Quality, Phytoplankton, Real-time Data	X

* Only when the surface specific conductivity is below 20,000 µS/cm.

Data availability and reporting: data are available online as excel files; annual water quality report.

2. California Department of Water Resources – Municipal Water Quality Investigations (MWQI)
Summary:

How and to what extent does it address Delta RMP assessment questions?

Data from the MWQI extends the spatial coverage of EMP for examining regional long-term trends. This includes stations upstream of the Sacramento urban area at the Sacramento River and American River and stations in the South Delta at the Old River and Middle River. The MWQI Delta Simulation Model 2 (DSM2) nutrient monitoring study and Cache Slough Baseline Monitoring extend the spatial coverage to the North Delta and Eastside, which are subregions of the Delta that are currently not monitored by EMP.

Opportunities

The MWQI Program tries to support the needs of other programs by providing resources for sample collection. There is a mutual interest in developing a pre-restoration baseline, particularly in the North Delta/Cache Slough Complex, and assessing the effects of planned habitat restoration activities on water quality. This include nutrients and nutrient-associated ecosystem responses, as they pertain to potential changes to in-stream drinking water quality.

Constraints

The MWQI sample collection is limited by resources and funding. The Cache-Slough Baseline Monitoring and the DSM2 nutrient study were planned and designed as short-term monitoring projects, even though they are to be continued indefinitely per current workplan.

Program Description: MWQI

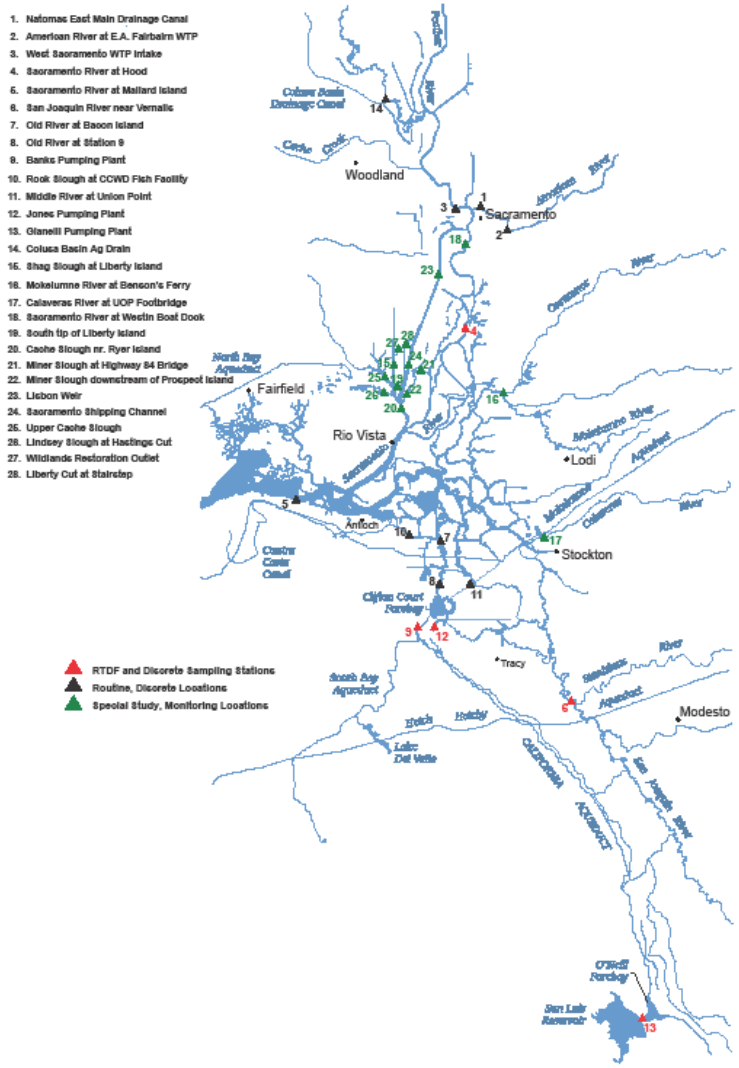
Related Goals and Activities: MWQI Program data are used in drinking water supply studies, to identify long-term trends in drinking water quality, and to help DWR and other agencies research and mitigate drinking water issues in Delta waters and the State Water Project (SWP). Additionally, in collaboration with the Bay-Delta Office and Operations & Maintenance Division, monitoring data are used to develop an "early warning" system that provides advance notice to Delta water users of possible drinking water quality problems. Aside from MWQI's routine monitoring, other samples are collected for short-term monitoring projects, including The Delta Simulation Model 2 (DSM2) nutrient monitoring study and Cache Slough Baseline Monitoring.

MWQI's Monitoring of Nutrients and Nutrient-associated Variables

Program Element	Start	Sampling frequency	Nutrients monitored	Nutrient-associated variables monitored
Routine Monitoring	1982	Monthly Grab sampling by boat	Ammonia, Kjeldahl nitrogen, nitrite + nitrate, organic nitrogen, ortho-phosphate, phosphorus	UVA, standard minerals, DOC, TOC, turbidity
Real-time Data and Forecasting (RTDF)	1982	Every 15 minutes	Nitrate	EC, TOC/DOC
DSM2 Nutrient Study	2013	Twice a month Grab sampling by boat	Ammonia, Kjeldahl nitrogen, nitrite + nitrate, organic nitrogen, ortho-phosphate, phosphorus	Physical parameters, biological oxygen demand (BOD), carbonaceous biological oxygen demand (CBOD), chlorophyll, and phaeophytin
Cache Slough baseline and monitoring analysis	2013	Twice a month Grab sampling by boat	Ammonia, Kjeldahl nitrogen, nitrite + nitrate, organic nitrogen, ortho-phosphate, phosphorus	Standard minerals, TOC, DOC, UVA, suspended solids, chlorophyll, phaeophytin

Sampling Locations:

Figure 2. MWQI Discrete and RTDF Monitoring Locations



Data availability and reporting: online: DWR Water Data Library (all data), CDEC (real-time data); annual reports; daily, weekly, and/or monthly emails to subscribers of distribution list.

3. California Department of Water Resources, North Central Region Office (NCRO) Water Quality Evaluations
Summary:

How and to what extent does it address Delta RMP assessment questions?

The NCRO does not monitor nutrients. This collection effort contributes to the spatial density of continuous and discrete chlorophyll data in the Confluence, Central Delta, South Delta, North Delta, and Sacramento River subregions. Including these data in assessments would increase statistical power for long-term trend detection in these subregions and contribute to a better understanding of the spatial variability of chlorophyll in these subregions.

Opportunities

Explore the feasibility of collaborating and piggybacking nutrient parameters to some of the 39 existing stations. Options for adding NO3 sensors to the existing sensors and additional analyses of discrete water samples could be explored.

Constraints

Monitoring stations for this program are limited to the Central and South Delta.

Program Description: NRCO Water Quality Evaluations

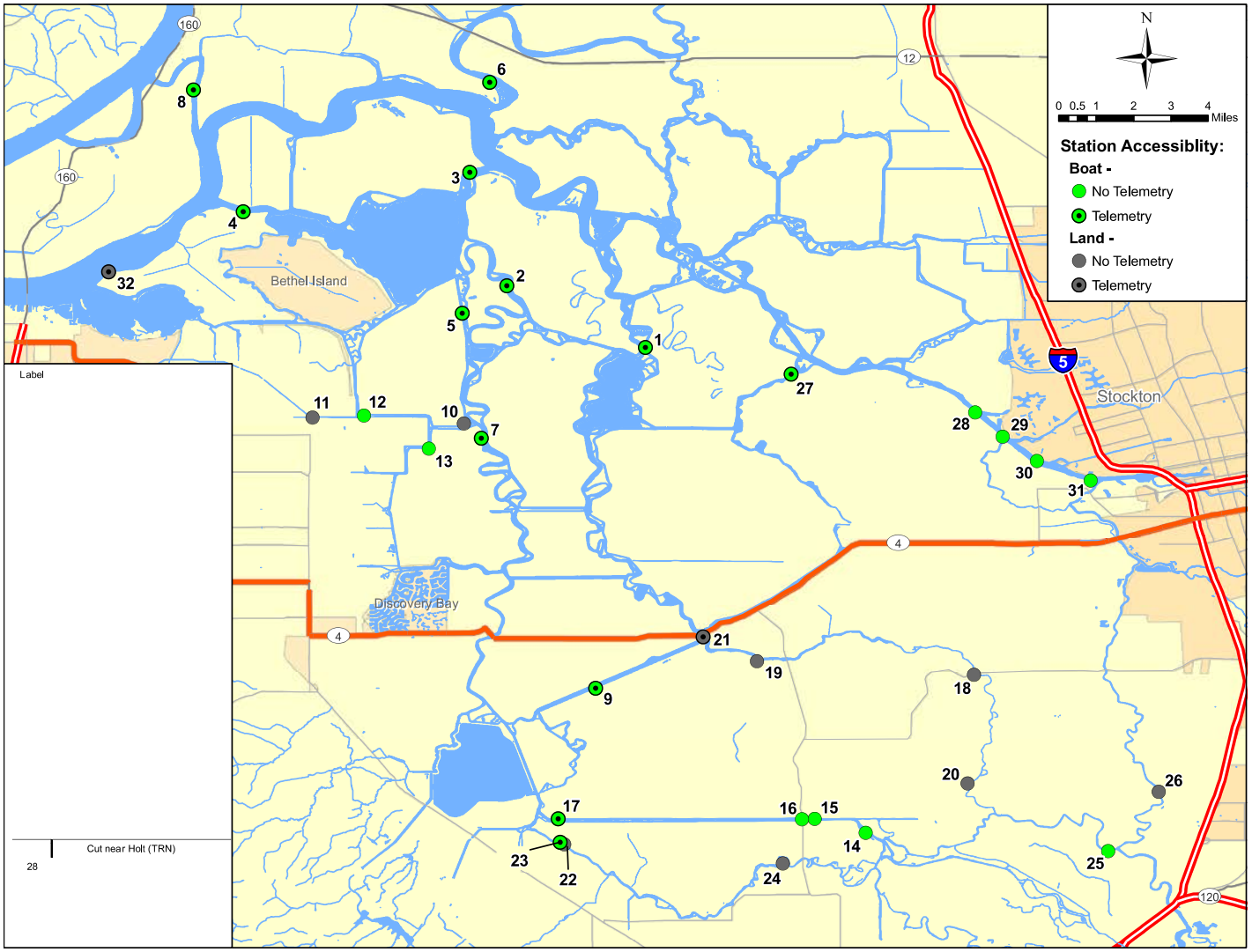
Related Goals and Activities: The Water Quality Evaluation Section out of DWR's North Central Region Office maintains a total of 32 time-series water quality stations encompassing three current Delta projects: Rock Slough Monitoring Program, South Delta Monitoring Program, and Central Delta Monitoring Program.

Each of these projects has specific objectives and monitors a specific suite of water quality constituents. Continuous water quality parameters that are collected include: water temperature, specific conductance, pH, turbidity, dissolved oxygen, and chlorophyll *a*. In addition, discrete water grab samples are obtained for analysis at DWR's Bryte Laboratory. The discrete constituents measured at many of the stations include chlorophyll *a*, phaeophytin *a,* and total suspended solids.

NCRO's Monitoring of Nutrients and Nutrient-associated Variables

Program Element	Sampling frequency	Nutrients monitored	Nutrient-associated variables monitored
Central Delta	Continuous (every 15-minutes) / Discrete (can vary from weekly to every 3 weeks	None	Chlorophyll, temperature, SC / Chlorophyll, phaeophytin, TSS
Rock Slough Monitoring	Continuous (every 15-minutes) / Discrete (can vary from weekly to every 3 weeks	None	SC, temperature
South Delta Monitoring	Continuous (every 15-minutes) / Discrete (can vary from weekly to every 3 weeks	None	Chlorophyll, DO, pH, temperature, turbidity SC / Chlorophyll, phaeophytin, TSS

Sampling Locations: Stations for the Central Delta, Rock Slough, and South Delta Monitoring are shown on the following map.



Data availability and reporting: online: DWR Water Data Library (all data), CEDEC (real-time data); technical reports.

4. DWR Special Studies Research Program
Summary:

How and to what extent does it address Delta RMP assessment questions?

This research effort makes significant contributions to our understanding of the development and occurrence of harmful algal blooms (HABs) in the Delta and the role of nutrient cycling and sources and other environmental factors in these conditions. However, it is not a routine long-term monitoring effort, which would be needed to address prioritized Delta RMP assessment questions as framed. The studies provide spatially and temporally limited information on ecosystem status (ST-2) relative to HABs and contribute to the scientific knowledge base for determining how these conditions are related to nutrients (ST-2A).

Opportunities

The DWR Special Studies Research Program would be a potential partner in the design, development, and maintenance of a long-term monitoring program for *Microcystis*. This DWR section has conducted special studies of *Microcystis* bloom biomass, cyanobacteria species composition, toxin production, and environmental conditions (including nutrients) in the Delta since 2003. Such studies have included the use of isotopes to study the relative importance of ammonium and nitrate as nitrogen sources to *Microcystis* blooms observed in 2007, 2008, 2014, 2015, and how sources of ammonium used by *Microcystis* vary spatially and temporally in the Delta (2015)

Constraints

Not a routine monitoring effort. There is no continued, long-term funding for *Microcystis* monitoring. Recent efforts have been funded as part of a larger Drought Response Program funded by IEP.

Program Description: DWR Special Studies Research Program

Related Goals and Activities: The DWR Special Studies Research Program designs and implements scientific studies to answer current ecosystem questions in the San Francisco Estuary Watershed. This includes the use of FlowCAM technology to characterize Delta plankton use of traditional and molecular methods to characterize harmful algal blooms and algal toxin production, und the use stable isotopes to characterize the role of nutrient cycling and sources in harmful algal bloom development. Ongoing Microcystis studies are currently focusing on the lower San Joaquin River. However, there is no ongoing regular data collection effort

Monitoring of Nutrients and Nutrient-associated Variables

Program Element	Sampling frequency	Nutrients monitored	Nutrient-associated variables monitored
Characterization of microcystin blooms and the role of nutrients and other environmental conditions in harmful algal bloom development	N/A	Ammonium, nitrate, phosphate; stable isotopes (NH4, NO3, PO4)	Microcystin, phytoplankton biomass and taxonomic composition.

Data availability and reporting:

Oral presentations and posters at professional meetings and science conferences, scientific publications, technical reports.

5. Sacramento Deepwater Ship Channel (U.S. Bureau of Reclamation, UC Davis, Central Valley Regional Water Board, USGS)

Summary:

How and to what extent does it address Delta RMP assessment questions?

This effort provides baseline data for nutrients and ecological conditions in under-monitored areas of the North Delta, including the Sacramento Deepwater Ship Channel (SDSC). These data help evaluate spatial and seasonal variability of nutrients and nutrient-associated variables in the North Delta.

Opportunities

Data from this project could help fill an existing data gap regarding spatial and temporal variability in nutrients, nutrient-associated parameters, and ecological conditions in the North Delta (Delta RMP assessment questions S&T1 and S&T2).

Constraints

This project is not a routine monitoring effort with long-term funding. It is a research project and the data are not readily accessible in a public database.

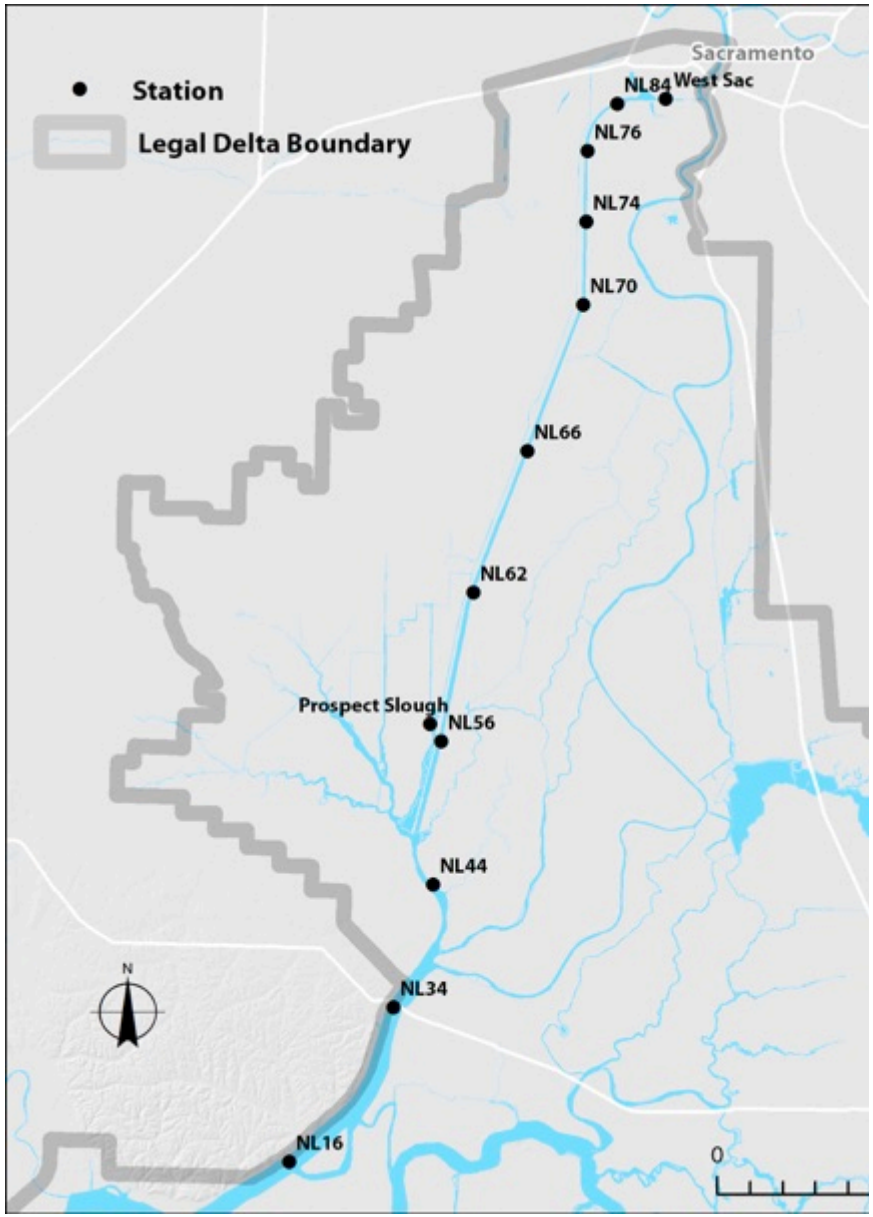
Project Description: Sacramento Deepwater Ship Channel

Related Goals and Activities: developing a baseline for experiments focused on increasing the food supply of the North Delta. Data are collected monthly in the spring, summer, and fall during 48hr boat runs scheduled to occur at low ebb tides. Monitoring occurs at 12 stations located in the Sacramento Deepwater Ship Channel (SDSC), the Prospect Slough stairstep, and Liberty Cut. Monitoring includes continuous YSI measurements and vertical nutrient profiles.

Monitoring of Nutrients and Nutrient-associated Variables

Program Element	Start	Sampling frequency	Nutrients monitored	Nutrient-associated variables monitored
SDSC baseline monitoring	2012	Monthly in the spring, summer, and fall	Ammonium, nitrate, soluble reactive phosphorus (SRP)	Temperature, specific conductance, turbidity, suspended solids, phytoplankton and zooplankton abundance and taxonomic composition.

Sampling Locations:



Data availability and reporting:

Data from this project have not yet been released and published, expect for oral presentations at professional meetings and science conferences.

6. USGS National Water Quality Assessment (NAWQA) Program
Summary:

How and to what extent does it address Delta RMP assessment questions?

The discrete monitoring conducted by the NAWQA program at the Freeport and Vernalis sites partially addresses Question ST-1 "How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally?" and touches on "How are ambient levels and trends affected by variability in climate, hydrology, and ecology?" by monitoring additional parameters such as flow, temperature, and DOC. The Vernalis and Freeport sites capture inflows from the Sacramento and San Joaquin, which account for the majority of all freshwater inputs to the Delta, thereby this monitoring program is very important for answering Question SPLP-1 "What are the loads from tributaries to the Delta?"

Opportunities

Additional discrete sampling targeting storms (2 to 3 high flow events) would provide better information to calculate load models for high discharge events. Sampling along the hydrograph to fully characterize short-term changes in various nutrient types would improve load estimates from the Sacramento and San Joaquin watersheds (SPLP-1 "What are the loads from tributaries to the Delta?")

Constraints

The NAWQA program captures some of the wet event variability by sampling 2x/month during some months in the wet season, but this sampling does not sufficiently capture the short-term variability in nutrient concentrations in relation to the hydrograph.

Program Description: NAWQA

Related Goals and Activities: The NAWQA program currently maintains monitoring stations at Freeport and Vernalis that represent terminus stations of the San Joaquin and Sacramento River Basin watersheds. The two stations are part of a of water quality monitoring stations representative of "study units" throughout the Nation to provide a framework for national and regional water-quality assessment.

Monitoring of Nutrients and Nutrient-associated Variables

Program Element	Start	Sampling frequency	Nutrients monitored	Nutrient-associated variables monitored
NAWQA	1991	14 events/year (Freeport)/18 events/year (Vernalis) Grab sampling from bridge (Vernalis)/by boat (Freeport)	Ammonia, nitrate, nitrite, total nitrogen, orthophosphate, total phosphorus, organic nitrogen.	Dissolved and particulate carbon, ultraviolet light absorbing constituents.

Sampling Locations:

Data availability and reporting:

Data are available on the USGS National Water Information System (NWIS: http://waterdata.usgs.gov/nwis); technical reports (nationwide assessments).

7. USGS High-Frequency (HF) Nutrient Monitoring Network

Summary:

How and to what extent does it address Delta RMP assessment questions?

The current HF nutrient sensor network operated by the USGS CAWSC Biogeochemistry Group provides continuous monitoring of nitrate, temperature, specific conductance, pH, DO, turbidity, chlorophyll-a, phycocyanin (pigment found in cyanobacteria), DOM fluorescence at key locations in the North Delta (Toe Drain, Deep Water Shipping Channel, Liberty Cut, Liberty Island, Cache Slough), Sacramento River (Freeport and Walnut Grove), Confluence (Decker, Jersey Point, Confluence) and South Delta (Vernalis). While some of these stations have been operated since 2013, others were only recently installed (Jersey Point and Confluence, see below table). The data these stations provide help evaluate the temporal variability for the measured parameters at these stations at multiple scales (diurnal, seasonal, annual, short-term ephemeral events). With respect to ranges in concentrations, data help assess spatial variability in the North Delta, Sacramento River conditions above and below the outflow of the Sacramento Regional Wastewater Treatment Plant, contributions for the San Joaquin River watershed to the Delta, and fluctuations in the Confluence region. Data help address most of the assessment questions:

- ST-1 – How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally?
- ST-1A – Are trends similar or different across subregions of the Delta? *(**For Sacramento River, North Delta, Confluence, and South Delta subregions**)*
- ST-1B – How are ambient levels and trends affected by variability in climate, hydrology, and ecology?
- ST2-A – St-2A could also be added: What is the current ecosystem status of habitat types in different types of Delta waterways, and how are the conditions related to nutrients?
- SPLP – 1A How have nutrient or nutrient-related source controls and water management actions changed ambient levels of nutrients and nutrient-associated parameters?
- SPLP-1B – What are the loads from tributaries to the Delta?
- SPLP-1C – What are the sources and loads of nutrients within the Delta?
- SPLP-1D What role do internal sources play in influencing
- observed nutrient levels?
- SPLP-1E – Which factors in the Delta influence the effects of nutrients?
- SPLP-1F – What are the types and sources of nutrient sinks within the Delta?
- SPLP-1G – What are the types and magnitudes of nutrient exports from the Delta to Suisun Bay and w
  Projects?

Opportunities

Augmented and sustained HF monitoring will help to (1) improve the assessment of long- and short-term changes, (2) understand the effects changing nutrient concentrations may have in different parts of the Delta, (3) quantify loads to and from the Delta, and (4), help

identify important sources, sinks, and nutrient-transforming processes in the Delta. Continued and improved HF monitoring at points were nutrients are entering and exiting the Delta will provide more complete answers to the assessment questions listed above.

Constraints

Due to technological limitations, it is not yet possible to continuously monitor all desired parameters in situ. In addition, the cost of implementing a high-frequency nutrient monitoring network can be quite large. Future funding for the existing nutrient stations has not yet been secured. For example, there is no funding available to implement a nitrate sensor at Vernalis.

Program Description: USGS HF Nutrient Monitoring Network

Related Goals and Activities: The overarching purpose of the ongoing USGS HF monitoring efforts in the Delta is to continuously measure the tidally dependent variation in nutrients and water quality to investigate their role and impact on habitat conditions and phytoplankton productivity. The goal of the project is to provide continuous real-time habitat status and trends information to managers and researchers and thereby to assist operational management and environmental assessment.

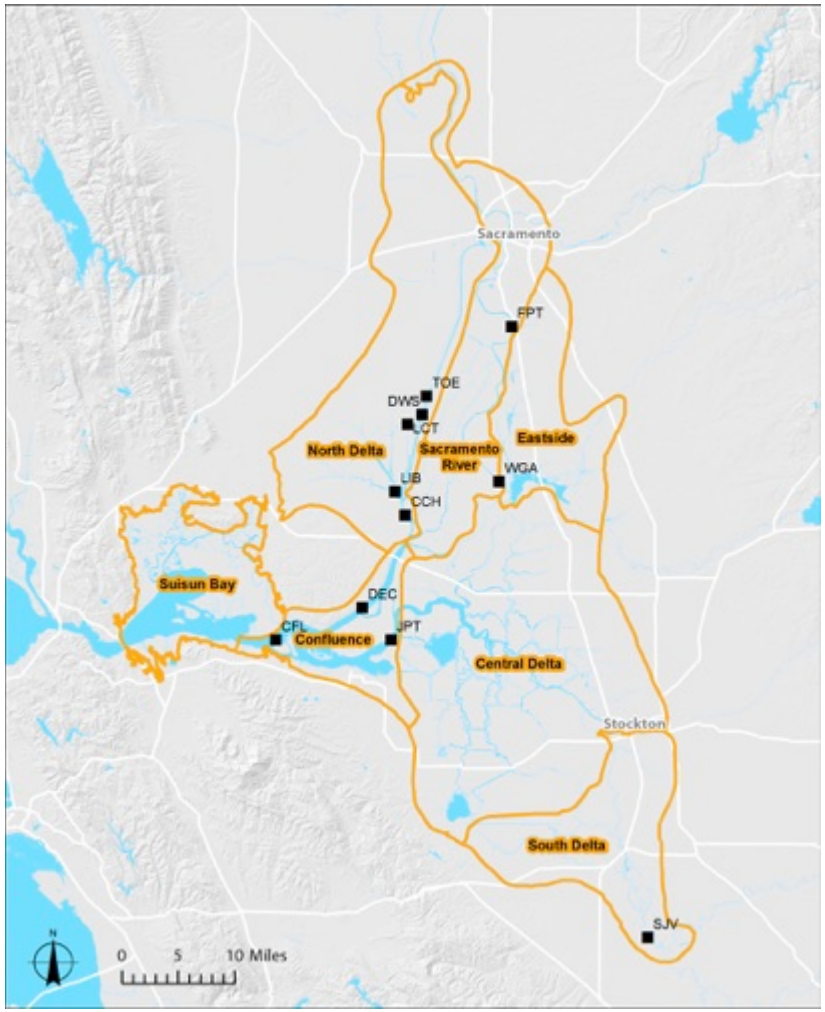
Monitoring of Nutrients and Nutrient-associated Variables

Program Element	Start	Sampling frequency	Nutrients monitored	Nutrient-associated variables monitored
HF monitoring network	2013 (see table on next page for details)	Continuous (15 minute sampling frequency)	Nitrate, phosphate (sensors deployed on an event basis), ammonium (under development)	Temperature, conductivity, pH, DO, chlorophyll-a, phycocyanin (a tracer for blue-green algae such as *Microcystis*), and fluorescent dissolved organic matter (fDOM, a proxy for dissolved organic carbon concentrations).

List of the USGS CAWSC Biogeochemistry Group's High Frequency water quality monitoring stations. All of these stations are currently equipped with a SUNA nitrate analyzer and YSI EXO2, with the exception of the station at Vernalis* (SJV) which does not have an EXO2 deployed. All of the EXO2 sondes are equipped to measure temperature, conductivity, pH, dissolved oxygen, turbidity, chlorophyll-a, phycocyanin (a tracer for blue-green algae such as *Microcystis),* and fluorescent dissolved organic matter (fDOM, a proxy for dissolved organic carbon concentrations). Station data are available on the USGS National Water Information System (NWIS: http://waterdata.usgs.gov/nwis). Deployment of in situ phosphate analyzers at these stations occurs on a project or event basis, and in situ ammonium analyzers are under development.

Site Name	Site Abbreviation	NWIS Station Number	Date Established	Latitude	Longitude
Freeport	FPT	11447650	8/30/2013	38.456111	121.500278
Walnut Grove	WGA	11447890	8/21/2013	38.257778	121.517222
Toe Drain North of Stair Steps	TOE	11455139	8/19/2014	38.365180	121.637730
Liberty Cut	LCT	11455146	1/31/2014	38.328850	121.667531
Deep Water Shipping Channel	DWS	11455335	4/11/2014	38.341667	121.643889
Liberty Island	LIB	11455315	7/15/2013	38.242222	121.686111
Cache Slough	CCH	11455350	2/1/2013	38.212778	121.669167
Decker Island	DEC	11455478	1/24/2013	38.093333	121.736111
Confluence	CFL	11455508	9/12/2016	38.04953	121.8755
Jersey Point	JPT	11337190	9/12/2016	38.05253	121.68834
San Joaquin River at Vernalis*	SJV	11303500	1/21/2015	37.676111	121.265278

Sampling Locations:



Data availability and reporting:

Station data are available on the USGS National Water Information System (NWIS: http://waterdata.usgs.gov/nwis)

8. USGS San Francisco Bay Water Quality Cruise

How and to what extent does it address Delta RMP assessment questions?

This program contributes to our understanding of long-term trends and spatial variability along a transect in Suisun Bay and the lower Sacramento River, including Rio Vista (ST1, ST1A).

Opportunities

Future collaboration with this program could potentially help address common questions about nutrients and ecosystem conditions that require data collection on a larger geographic scale across the Bay and Delta.

Constraints

The sampling design and monthly cruise schedule are designed to meet long-term water quality data needs for San Francisco Bay. Sampling is limited to a relatively small portion of the Delta and the timing of sampling relative to the tide is different from the EMP, which samples within a one-hour window of the expected occurrence of high tide slack at a sampling location.

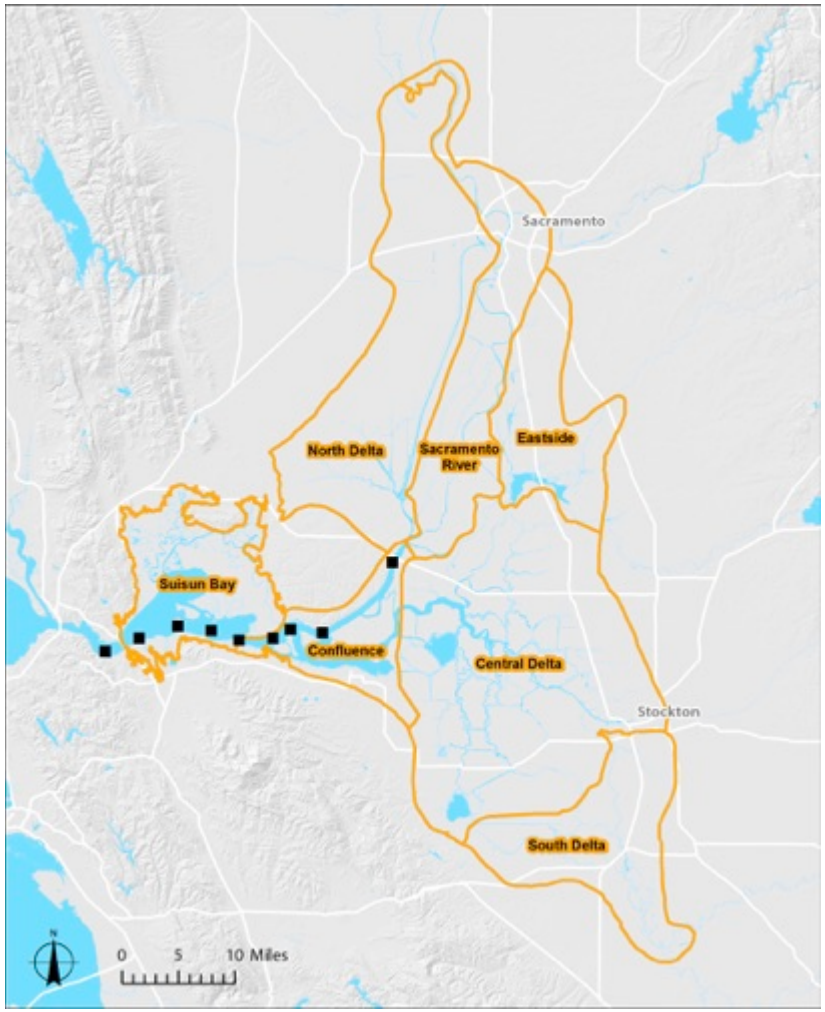
Program Description: USGS HF Nutrient Monitoring Network

Related Goals and Activities: The program includes regular measurements of water quality along a 145 kilometer transect spanning the length of the entire estuarine system, at 37 fixed sampling locations spaced 3-6 kilometers apart. These sampling stations are located along the central deep channel, from the southern limit of South Bay, through Central Bay, San Pablo Bay, Carquinez Strait, Suisun Bay, and ending at Rio Vista on the Sacramento River.

Monitoring of Nutrients and Nutrient-associated Variables

Program Element	Start	Sampling frequency	Nutrients monitored	Nutrient-associated variables monitored
North Bay/Full Bay cruises	1969	Monthly	NO_2, NO_{3+2}, NH_3, PO_4, and dissolved Si	Salinity, temperature, suspended particulate matter, dissolved oxygen, light penetration, and chlorophyll concentration

Sampling Locations:



Data availability and reporting: data can be queried and visualized on "Access USGS--San Francisco Bay & Delta" (http://sfbay.wr.usgs.gov/). The website also provide access to numerous research publications and technical reports based on this dataset.

9. Regional San - Monitoring of Sacramento River Receiving Waters and Upstream Waters
Summary:

How and to what extent does it address Delta RMP assessment questions?

Regional San's monitoring tracks seasonal changes in nutrients upstream and downstream of the Sacramento Regional Wastewater Treatment Plant. A 2016 research survey takes snapshots of nutrient concentrations and other actors that potentially affect phytoplankton growth within the Sacramento River (from RM 95 to RM 19). These activities partially address question ST-1 for the Sacramento River mainstem within the Sacramento River subregion and upstream of the Delta ("How do concentrations of nutrients (and nutrient-associated parameters) vary spatially and temporally?"). The research survey also contributes to the data and knowledge base for addressing questions ST-2 ("What is the current status of the Delta ecosystem as influenced by nutrients?") and ST-2A ("What is the current ecosystem status of habitat types in different types of Delta waterways, and how are the conditions related to nutrients?"). Regional San (and other POTWs) also conduct effluent monitoring, which is important for answering SPLP questions.

Opportunities

Regional San's research program contributes to studies evaluating the potential ecosystem effects of different nutrient concentrations and forms (ST-2).

Constraints

Regional San is a small organization relative to others conducting nutrient and ecological studies in the region and depends on successful collaborations to address questions of interest on a larger ecosystem scale.

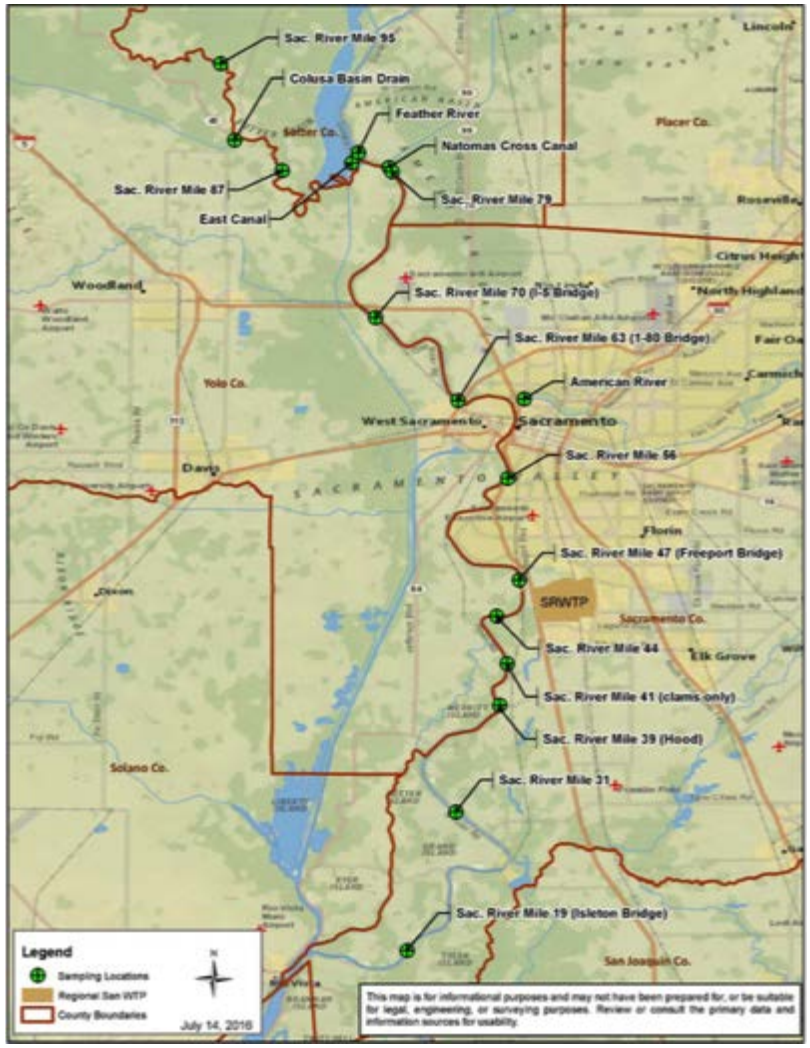
Program Description: Regional San - Monitoring of Sacramento River Receiving Waters and Upstream Waters

Related Goals and Activities: Regional San collects ambient nutrient data as part of research studies in the Sacramento River and Delta and conducts monthly monitoring of ambient conditions upstream and downstream of the effluent diffuser in the Sacramento River. The research studies are investigating the factors regulating phytoplankton growth. Furthermore, Regional San funds the USGS nutrient sensor at Freeport (However, there is no long-term funding commitment. See USGS High-Frequency (HF) Nutrient Monitoring Network).

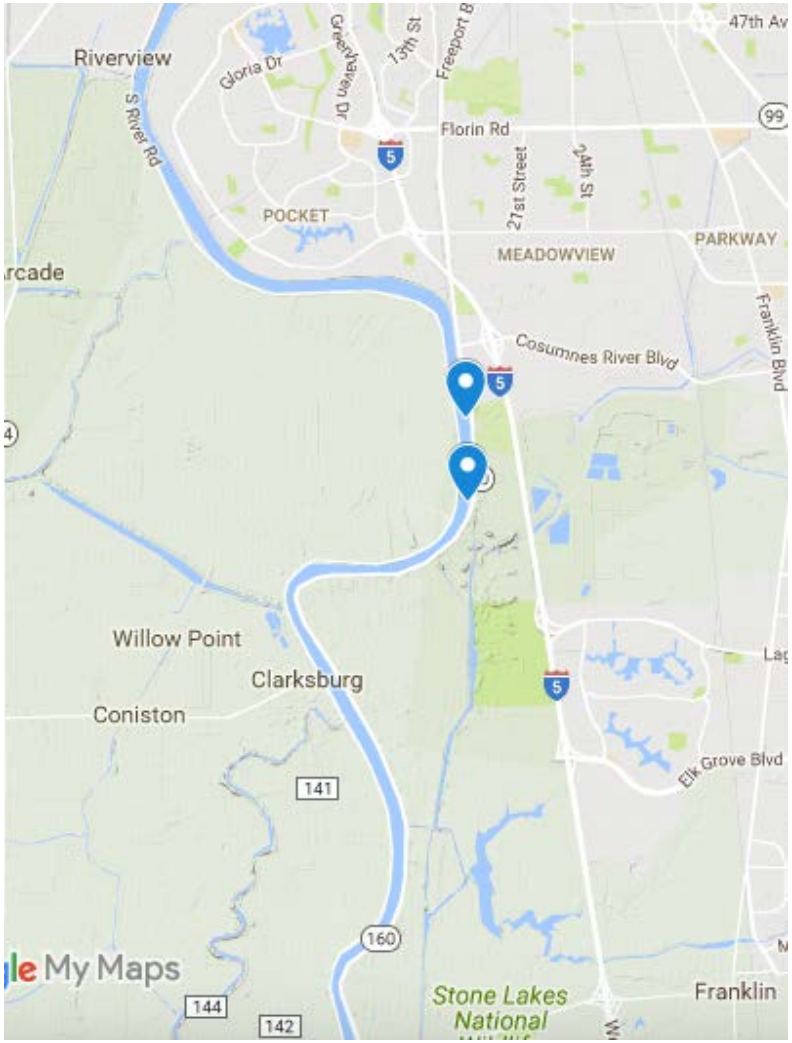
Monitoring of Nutrients and Nutrient-associated Variables

Program Element	Start	Sampling frequency	Nutrients monitored	Nutrient-associated variables monitored
Research Survey	2016 (1-year duration)	Intensive one-time surveys in spring and fall of 2016 (RM19 to RM95), combined with monthly sampling at RM44	Ammonium, nitrate + nitrite, Kjeldahl N, phosphate, silicate, uptake experiments (NH4+C, NO3+C)	Temperature, turbidity, pH, EC, DO, chlorophyll, photosynthetically active radiation (PAR), picoplankton, phytoplankton, isotopes, microzooplankton, macrozooplankton, clams
Ambient water quality (Receiving Water)	2010	Monthly at 2 stations (Freeport Bridge and Cliff's Marina)	Ammonium, total N	

Sampling Locations for Regional San 2016 research survey:



Regional San Receiving Water Monitoring Stations



Data availability and reporting:

Presentation at scientific conferences, project reports, manuscripts, response to Requests for Information.

10. Stockton RWCF - Monitoring of Receiving Waters
Summary:

How and to what extent does it address Delta RMP assessment questions?

Receiving water monitoring tracks seasonal changes in ammonium and ambient water quality parameters upstream and downstream of the Stockton Regional Wastewater Control Facility. This monitoring contributes data to assess question ST-1 for the San Joaquin River up- and downstream of the facility and (combined with effluent data) helps to evaluate loadings from this source (SPLP-2C "What are the sources and loads of nutrients within the Delta?" and SPLP2D "What role do internal sources play in influencing observed nutrient levels?"

Opportunities

Potential piggybacking of monitoring parameters.

Constraints

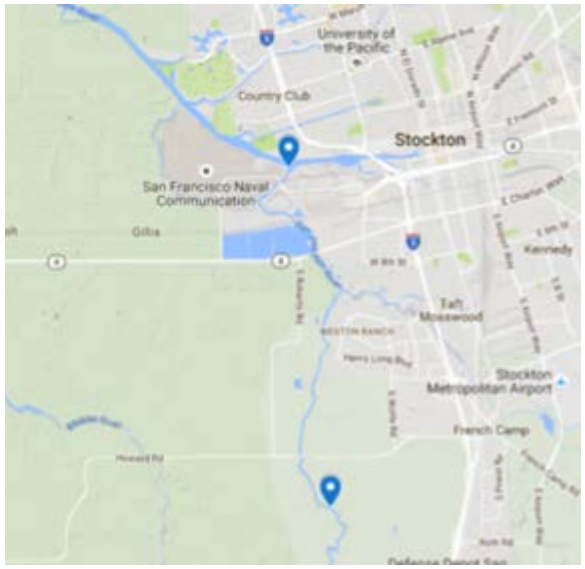
The City of Stockton has a small monitoring program relative to others described here with a very local scope.

Program Description: Stockton RWCF - Monitoring of Receiving Waters
Related Goals and Activities: The Stockton RWCF monthly conducts monitoring of ambient conditions upstream and downstream of the effluent diffuser.

Monitoring of Nutrients and Nutrient-associated Variables

Program Element	Start	Sampling frequency	Nutrients monitored	Nutrient-associated variables monitored
Ambient water quality (Receiving Water)	1992	Monthly at 2 stations	Ammonium	EC, pH, temperature, turbidity, DO

City of Stockton Receiving Water Monitoring Stations



Data availability and reporting:

Presentation at scientific conferences, project reports, manuscripts, response to Requests for Information.

Appendix B: List of Acronyms

ASC	Aquatic Science Center
BOD	biological oxygen demand
C	carbon
CASCaDE	Computational Assessments of Scenarios of Change for the Delta Ecosystem
CBOD	carbonaceous biological oxygen demand
chl-a	chlorophyll a
DO	dissolved oxygen
DOC	dissolved organic carbon
DSM2	Delta Simulation Model 2
DWR	California Department of Water Resources
EC	electric conductivity
EMP	Environmental Monitoring Program
FAV	floating aquatic vegetation
fDOM	fluorescent dissolved organic matter
FS	Forecasting Scenarios
GAMs	general additive models
HF	High-frequency
IEP	Interagency Ecological Program
MWQI	Municipal Water Quality Investigations
N	nitrogen
NAWQA	National Water Quality Assessment
NCRO	North Central Regional Office
NDO	net Delta outflow
NH4	ammonium
NO3	nitrate
nr	near
N/A	not applicable
OC	organic carbon
P	phosphorus
PO4	phosphate
RM44	River Mile 44
RMP	Regional Monitoring Program
RTDF	Real-Time Data and Forecasting
SAV	submerged aquatic vegetation
SC	specific conductance
SDSC	Sacramento Deepwater Ship Channel
SCHISM	Semi-Implicit Cross-scale Hydroscience Integrated System Model
SPLP	Sources, Pathways, Loadings, and Processes
SRP	soluble reactive phosphorus
ST, S&T	Status & Trends
SWP	State Water Project
TBD	to be determined
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
USGS	U.S. Geological Survey
UV	ultraviolet
UV	ultraviolet A
VSS	volatile suspended solids
WRTDS	weighted regressions on time, discharge, and season

Appendix C: References

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Materials for Agenda Item 9

Pesticides Prioritization Process – *Revised*

October 2016

Stephen McCord, Ph.D., P.E.

MCCORD ENVIRONMENTAL

Why re-evaluate target pesticides now?

- 7/20/16: SC request to update target list of pesticides
- 8/16/16: Coord. Committee
  - Prioritize for FY17/18 Workplan (April '17)
  - ASC work with TAC and Pesticide Subcom.
- Economize the RMP budget

2

Annual Planning Process*

- January: High-level updates to assessment questions and Monitoring Design
- April: Detailed workplan and budget
- May: Updated analytes, protocols, and design in QAPP

** Source: Program Planning Overview (approved 12/18/15)*

3

Management and Assessment Questions

Mgmt Q.

- Is there a problem or are there signs of a problem?

S&T Assess Q1

- To what extent do current use pesticides contribute to observed toxicity in the Delta?

S&T Assess Q1.1

- **Which pesticides or degradates have the highest potential to be causing toxicity in the Delta and therefore should be a priority for monitoring and management?**

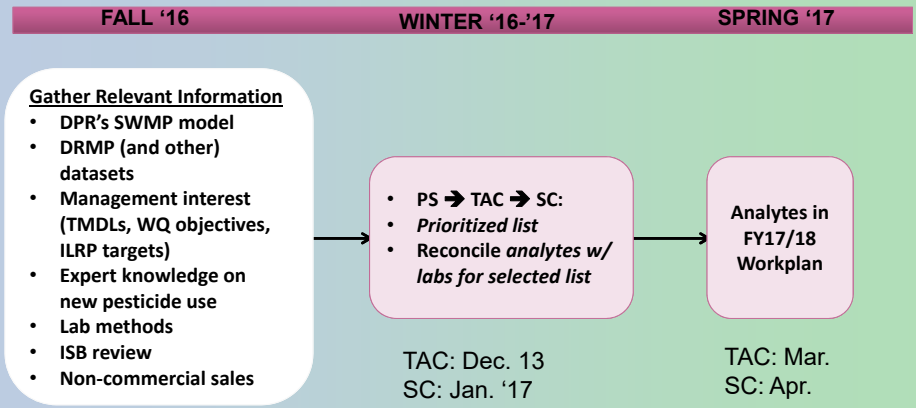
4

Key Considerations

- Cost$ vs. benefits of more analytes
- No formalized prioritization process
  - Factors
  - Schedule
- USGS lab most comprehensive, but still incongruous with "priorities"
  - Some priorities not monitored
  - Some monitoring not priorities
- Changing analytes ➔ design, workplan, QAPP, contracts
- Uploading <u>all</u> results to NWIS

5

Proposed Process and Schedule for prioritizing pesticides for monitoring



6

Proposed Process

- Today: Feedback on issues & process
- Oct: Develop weighting factors
- Nov: Draft selected list

SC/TAC mtg. Oct. 18

- Dec: TAC approve selected list
- Jan: SC endorse methods and prioritized list
- Mar: TAC recommend FY17/18 analytes
- Apr: SC approve analytes & lab(s) in FY17/18 Workplan

7

Selection Process Options

Prioritization Table?

---------- DPR --------- ILRP ---------- Data ---------- Judgment

rget alyte	Analyt. method	Use score[1]	Toxicity score[2]	Recom-mended[3]	Recom. by ILRP Advisory WG[4]	Detected by Delta RMP[7]	Detected by others[8]	Toxicity / threshold exceeded[9]	Antici-patory[10]
A B C … Z		X	X	X	X	X	X	X	X

Decision Tree?

➔Essential, high priority, nice, OK if free

Also consider:

- Regulatory drivers (TMDLs, permits, policies)
- Type of application / Delta WQ relevance

8

Charge to Subcommittee

- Add technical experts on subcommittee as needed
- Generate bins of target pesticides
  - Address Mgmt. Question
  - Rectify priorities w/ lab capabilities
  - Generate custom analyte lists for labs
- Report back to TAC on Dec. 13

9

Next Steps?

- Tabulate lab costs, analytes
- Gather Relevant Information (slide 7)
- ??

10

Delta Regional Monitoring Program (RMP)

Technical Advisory Committee (TAC) Meeting

September 20, 2016
12:30 – 4:30 PM
Central Valley Regional Board, 11020 Sun Center Drive #200, Rancho Cordova, CA

Summary

Attendees:
TAC (and/or Alternate) members present[1]*:*
Stephanie Fong, Water Supply (State and Federal Contractors Water Agency)
Brian Laurenson, Stormwater – Phase I (Larry Walker Associates)
Stephen McCord, TAC co-Chair (McCord Environmental, Inc.)
Mike Johnson, Agriculture (MLJ LLC)
Tim Mussen, POTWs (Regional San)
Debra Denton, Regulatory – Federal (U.S. EPA Region 9)
Tony Pirondini, POTWs (City of Vacaville)
Hope Taylor, Stormwater – Phase I (Larry Walker Associates)
Danny McClure, Regulatory – State (Central Valley Water Board)
Janis Cooke, Regulatory – State (Central Valley Water Board)
Lisa Thompson, POTWs (Regional San)
Tessa Fojut, Regulatory – State (Central Valley Water Board)
Melissa Turner, Agriculture (MLJ LLC)
Joe Domagalski, TAC co-Chair (U.S. Geological Survey)
Karen Ashby, Stormwater – Phase II (Larry Walker Associates)
Dawit Tadesse, Regulatory – State (State Water Board)
Amy Phillips, Stormwater – Phase II (El Dorado County)

By phone:
Shaun Philippart, Coordinated Monitoring (IEP/DWR EMP)

Others present:
Patrick Morris, Central Valley Regional Water Board
Thomas Jabusch, SFEI-ASC
Selina Cole, Central Valley Regional Water Board
Rachel Kubiak, Western Plant Health Association
Jim Orlando, USGS
Yumiko Henneberry, DSP
Armand Ruby, Armand Ruby Consulting
Phil Trowbridge, SFEI-ASC

[1] *Name, Representing Category (Affiliation)*
Version Date: 09/22/16

Marie Stillway, UC Davis AHPL
Josie Tellers, City if Davis (SC representative for POTWs)
Cam Irvine, CH2M
Scott Wagner, DPR
Dave Tamayo, Sacramento County (SC representative for Stormwater – Phase I)
Val Connor, GEI (SC representative for Water Supply)

1.	**Introductions and Agenda** Item #8 Process for Pesticide Prioritization and Schedule was moved up before Item#7 to allow participation by TAC members who needed to leave the meeting early.
2.	**Approve Draft TAC Meeting Summary (June 14, 2016)** The meeting summary was unanimously approved.
3.	**SC Updates** TAC co-Chairs summarized the outcomes of the July 20 SC meeting.
4.	**Update/Decision: Update on Monitoring Activities and Recommend ASC Technical Reports for SC Approval** ASC prepared two technical reports: 1) Quality Assurance (QA) Report for Year 1 Pathogens Data, and 2) FY15/16 Pesticides Field Sampling Report. Both reports were recommended for approval, with no objections. The QA report for pathogens data contained no surprises and concluded that the obtained data are generally low-biased lower bound estimates. The bias is inherent in the method used (USEPA1622/23), which is the standard method for assessing source waters for drinking water treatment plants. The Pesticides Field Sampling Report documents field sample collection, any deviations from the field sampling procedures described in the Quality Assurance Project Plan (QAPP), and field conditions on the days of sampling. Laboratory results will be presented in another report by February 1, 2017. TAC members had several suggestions for improvements and minor revisions. The RMP's Nutrient Monitoring Workshop will be held Sept. 30. The meeting is open, so any interested stakeholders contact Thomas for information. The QAPP was also adjusted to address logistical constraints for sampling for mercury. Samples are collected with bottles rather than flow-weighted composites.

	Recommendations: - The pathogen QA report was recommended for SC approval - Pesticides Field Sampling Report was recommended for SC approval with the following changes: ▪ Graph showing Delta flows and sampling days: separate graphs for Sacramento and San Joaquin rivers, to make it easier to see flows in the smaller tributaries ▪ Consider including MWQI real-time data for comparison, at co-located stations (i.e. Hood and Vernalis) ▪ Separate box plots for water quality parameters (water temperature etc.) at individual sites ▪ Include corrective actions and field recommendations for QA issues and deviations from QAPP that have occurred ▪ More explanation about deviations of sampling depth, number of QC samples for each parameter (e.g., toxicity blank samples), and hold times from those defined in the QAPP
5.	**Update: USGS High Frequency Sensor Report** USGS staff provided a status update and explained the steps involved in the USGS review and publication process. The group discussed at which step in this process the final TAC review and SC approval should occur, and the timing. Recommendations: - Present the next revision endpoint (draft to be submitted to the next level of USGS supervisory/scientific review and response letter) for general approval at the Oct 18 SC/TAC meeting, including a summary of comments received in the USGS review and of the responses. The report will go through additional USGS review and edits after this but the substance of the report will not change.
6.	**Information: DPR's Evaluation of Pesticide Use and Concentrations in CA's Surface Waters** DPR staff provided an overview of the Surface Water Prioritization Model, which is a decision support tool for prioritizing pesticide analytes for surface water monitoring projects. The Model incorporates two processes: 1) pesticide ranking according to use amounts and toxicity data, and 2) pesticide screening based on historical monitoring results, physical-chemical properties, registered use sites, and application methods. Pesticide use report (PUR) data are available for agricultural,

	urban (only those applied by commercial applicators), and "Right of way" uses. The model provides a scientifically defensible decision basis for prioritizing pesticides but also has limitations that users should recognize. Meeting participants pointed to some of the limitations with PUR data, including lag time (normally 2 years behind) and the lack of reporting for uses by homeowners. It was suggested that home uses could be roughly estimated from sales at the county level.
8.	**Discussion: Process for Pesticide Prioritization and Schedule** At the July 20 Steering Committee meeting, there was consensus on the need for a process to review and update the list of pesticide analytes reported by the Delta RMP. The main purpose of this agenda item was to agree on a process and a schedule for updating the Delta RMP's list of pesticide analytes. The group agreed on a planning process that would result in an updated list of pesticide analytes by April 2017, in time for inclusion in the FY17/18 Workplan. There was agreement that the process could be somewhat iterative. The following recommendations were provided and will be brought to the SC for confirmation at the October 18 SC/TAC joint meeting: <u>Recommendations:</u> - The proposed process would involve two (remote) meetings of the Pesticides Subcommittee. The charge of the subcommittee would be to develop a process for prioritization, including guidance on what type of system to use (i.e. bins vs. decision tree) as well as proposed weighting factors and/or criteria. It was agreed that a system of bins or a decision tree to group pesticides into different categories would be more useful than a straight ranking of pesticides (e.g., 1-200). - A first Subcommittee meeting, to be scheduled in October, would deal with the prioritization approach and the initial prioritization of pesticide analytes. The prioritization could be informed by the output from DPR's SWMP model, along with factors such as preliminary Delta RMP data and other datasets, management interest (TMDLs, water quality objectives, ILRP's prioritized analytes), expert knowledge on new pesticide use, and any relevant comments from the Independent Review Panel. - The second Pesticide Subcommittee meeting would be scheduled in November, with the aim of "rectifying" the initial prioritization against available analytical methods, method detection limits, and potential laboratories.

	- Stephen McCord would lead the meetings, with coordination and technical support provided by ASC. - The TAC would review the prioritized and "rectified" list of analytes in its December 13 meeting. - The SC would provide a budget range in the Oct. 2016 joint meeting, and would approve the prioritization process and prioritized ("selected") list of analytes in its January 2017 meeting.
7.	**Information: Update on Pyrethroids TMDL** Regional Water Board staff provided an update on the Central Valley Pyrethroid Pesticides TMDL and Basin Plan Amendment and discussed a potential monitoring nexus with the Delta RMP. After a Dec. 2016 hearing, Regional Board approval of the TMDL and Basin Plan Amendment are expected in 2017. TMDL monitoring is expected to start in 2018 or 2019, depending on how long it would take the U.S. EPA to approve the TMDL. The Regional Board is also proposing a general pyrethroids control program that would apply to all dischargers that are not subject to the TMDL. Monitoring related to the pyrethroids control program would be more likely to being in 2018. The regulatory documents provide language that would allow data collection through a regional or statewide program. However, the monitoring needs for TMDL implementation and the Delta RMP's monitoring design for pesticides currently don't match up. The Delta RMP monitoring data is expected to provide some ambient water quality context for the TMDL but does not specifically represent the small urban streams listed for pyrethroid impairments or sites that are representative of certain land uses. TAC members generally agreed that there would be inherent value in having both sets of data.
10.	**Discussion: Joint TAC-SC Meeting (October 18th) – Planning for the meeting** (Discussed out of sequence. There was a logical segue from the discussion of Basin Plan Amendments to the discussion of the Management Drivers Table for the joint TAC-SC planning meeting.) TAC members reviewed a table of existing and upcoming policy decisions and management drivers for the upcoming joint SC/TAC planning meeting. The pyrethroids TMDL entry on the table should note that monitoring will start in 2018 or 2019. One of the upcoming priorities in the Central Valley will be a regional pilot study on contaminants of emerging concern (CECs). This issue will be discussed at the SC/TAC meeting on October 18. TAC members also commented that a few items are missing from the table: pesticide-related TMDLs, EcoRestore, and DO in the Stockton Deep-water Ship Channel
9.	**Information: Toxicity - Update on FY15/16 Activities and Plans for FY16/17**

	AHPL staff presented a summary of the FY15/16 toxicity results. The results are captured in a case narrative document that will be included as a Technical Appendix to the Pesticide Annual Data Summary Report. The monitoring data report is planned for February 2016. It will present the combined chemical-analytical and toxicity testing results. <u>Recommendations:</u> - The report should have a cover memo indicating that it will be a technical appendix of the FY15/16 Current Use Pesticides and Toxicity Monitoring Report. - TAC members have one month for comments on the report.
11.	**Updates and wrap-up** Nutrient Monitoring Planning Workshop - The Workshop will be held on September 30, with the main goal of developing recommendations for "no regrets" monitoring and analyses that the Delta RMP could implement Pesticides - The Regional Board has contracted UC Davis AHPL for a new study on the toxicity of herbicides on algae native to the Delta. The list of herbicides to study is currently being narrowed and the experimental work is expected to begin later this year. Supplemental Environmental Projects (SEPs) - The Regional Board is looking for funding ideas for SEPs from the Delta RMP. TAC members are encouraged to coordinate with their SC representatives and develop ideas for Delta RMP projects at different funding levels. These ideas would be discussed and prioritized at the joint meeting. Proposed activities for which there isn't enough Delta RMP funding to be fully implemented could be proposed for upcoming SEPs. External Science Panel Review - Delta Science Program staff will receive the first draft of the review on Thursday, September 22. Shortly after, the External Review planning committee will meet to discuss the review and how to respond. Several members suggested adding more TAC representation on the planning committee. The suggested way forward is to a) a preliminary response by the planning committee (mainly how to provide missing information), and b) having additional technical people involved in the final response.

	Next TAC Meetings - December 13 and March 14 - TAC members commented that TAC Meetings should be longer to allow more time for important discussions. At the December 13 meeting, there should be more time to discuss the pesticide prioritization and the external science panel review Action Items *Nutrient Sensor Synthesis Report* - Send report including reconciled comments to TAC and SC (Joe Domagalski, by October 11) *Pesticide Prioritization* - Modify the slides for the proposed process for pesticide prioritization before including them in the Oct 18 SC/TAC meeting agenda package or sending them to the Pesticides Subcommittee (Stephen McCord, by October 4) - Send Doodle poll for first Pesticides Subcommittee Meeting (Thomas Jabusch, by September 22) – *Done.* - Add a cover page to the toxicity report that explains how it fits into the overall reporting plan (Thomas Jabusch, by December 6) *Joint TAC-SC Meeting* - Send comments on management drivers table and Section 7B (TAC) of the approved Delta RMP Charter to Phil Trowbridge (all TAC members, by October 4) - Prepare slides about the TAC roles and responsibilities in the Charter and share them with the TAC for review before the October 18 meeting (Stephen McCord by 10/17).

Parking Lot

- Vote on TAC co-chairs and confirm TAC membership at next meeting.
- Identify opportunities for Delta field experience by TAC members
- Pesticides
  - Benchmarks

Materials for Agenda Item 12

DATE: October 8, 2016

TO: Delta RMP Steering Committee

FROM: Philip Trowbridge, Selina Cole, and Patrick Morris

RE: Delta RMP Projects Eligible for SEP Funding

Requested Action

A proposed list of Delta RMP projects that could be eligible for SEP funding is shown in Table 1. Short descriptions of each project are provided after the table. If the Steering Committee approves this list, these projects will be immediately available as SEP options during penalty settlement negotiations.

Background

Introduction

On February 19, 2016, the Central Valley Water Board approved a resolution that made the RMP an authorized Supplemental Environmental Project (SEP) funds administrator (Attachment A). Therefore, for an enforcement action against a discharger, the discharger has the option to direct up to half of the penalty to the Delta RMP as a SEP.

As part of settlement negotiations for discretionary ACL settlements (ACLs) and non-discretionary ACLs (minimum mandatory penalties) , the Central Valley Water Board will direct dischargers to projects eligible for SEP funding, including the projects that have been vetted by the Delta RMP, as options during the ACL settlement negotiations.

Requirements for Delta RMP Projects to be Eligible for SEP Funding

The State Water Resources Control Board SEP Policy requires a nexus between the violation and the SEP. There is a general nexus between the Delta RMP and violations in the Delta and Central Valley because the Delta RMP monitors water bodies that are potentially affected by violations in the Delta and in the watershed draining to the Delta. If necessary, studies with a more specific nexus to the violation (e.g., geographical) could be identified through the RMP planning process.

The SEP Policy requires that the SEP must "go above and beyond" other applicable obligations of the discharger that proposes to satisfy a part of its monetary penalty with a SEP. Therefore, SEP funds must be used to implement only those elements of the Program that would not otherwise be implemented through the base funding for the Program.

Eligible RMP projects for SEP funding are monitoring or special studies that have been reviewed and recommended by RMP Technical Advisory Committee and approved by the Steering Committee, but not funded. The Steering Committee will maintain a list of eligible projects that can be used by the Water Board during settlement negotiations. The list will reflect the priority un-funded science needs of the Delta RMP at that time and is subject to change by the Steering Committee at any time.

Budgeting

SEP funds earmarked for a specific project cannot be reallocated by the Steering Committee to any other project.

Settlements less than $20,000 are difficult for the Delta RMP to implement as independent projects that provide regional information. The time and coordination needed to take advantage of smaller settlements offsets the benefits of the increased revenue. Therefore, the Delta RMP will develop projects for settlements greater than $20,000.

In addition, there are limitations on the types of costs that can be wrapped into the SEP. The State Water Board's Policy on SEPs (SEP Policy) states that, "… as a general rule, oversight costs are not costs that should be considered part of the direct cost of the SEP." This means that the costs associated with ensuring that the SEP is completed as proposed, and the costs associated with relaying this information to the Central Valley Water Board, cannot be paid for through the use of SEP funds. When an ACL Settlement is approved that includes a SEP that requires the Central Valley Water Board to perform oversight work, the SEP Policy requires that the discharger cover such costs incurred by the Central Valley Water Board. However, the SEP Policy also states that a discharger can arrange for a third party (which would, in this case, be ASC) to oversee the timely and adequate completion of the SEP. In this case, the discharger would either pay a small oversight fee to ASC, or ASC would need to agree to absorb such oversight costs. It may be the case that agreeing to cover such oversight costs would incentivize SEPs that would not otherwise get funded. Attachment B details the oversight costs that will be charged by ASC for administering the SEP projects for the Delta RMP.

Reporting

The Water Board will communicate with the Steering Committee members about upcoming settlements as much as possible without compromising the negotiations.

Data and technical reports prepared for SEP projects will be reviewed and approved by Delta RMP committees following the normal procedures in the approved Communications Plan.

Table 1. Delta RMP Projects Eligible for SEP Funding

Project	Budget Range	Oversight Group
Implement un-funded portion of Monitoring Design for pesticides/toxicity	$74,200-$155,000	Pesticide Subcommittee TAC
High Frequency Water Quality Mapping Campaigns	$105,000-$178,500	Nutrient Subcommittee TAC
Mercury Monitoring Implementation, Data Management, and Reporting	$144,000	Mercury Subcommittee TAC

Study Description for Supplemental Environmental Project Funds

Study Budget

Delta Regional Monitoring Program (RMP)
Pesticides and Toxicity Project by the Aquatic Science Center (ASC)

Study Budget, Total	$74,200*
ASC Subcontractor Coordination Costs (10%) Subcontractor Costs[1]	$7,420 $66,780
ASC Oversight Cost (3%)	$2,226*

*This cost will be paid for by the Discharger

Study Description

The Delta RMP is currently implementing the Low ("Bare Bones") level of monitoring described in the monitoring design. The goal of this study is to implement Delta RMP current use pesticide (CUP) monitoring at **3 additional sites** (see Table 1) in the Delta that are not currently funded fiscal year 16/17. The monitoring includes event-based sampling for three targeted events (n = 3/year): **2 Wet weather** - (1) 1st seasonal flush (Water Year), (2) Significant winter storm; **1 Dry weather** - (1) Late spring/early summer irrigation season. All samples will undergo the same chemical analyses and toxicity testing that is currently being implemented for the monthly CUP monitoring.

Test species (endpoints) are: (1) *Selenastrum capricornutum* (growth) (2) *Ceriodaphnia dubia* (survival and reproduction), and (3) *Pimephales promelas* (larval survival and growth). Chemical analysis includes: pesticide scan (USGS list of 153 pesticides), total suspended solids, dissolved organic carbon (DOC) and particulate organic carbon (POC), hardness, and dissolved copper analysis. Pesticide-focused Toxicity Identification Evaluations (TIEs) are conducted for a subset of samples with > 50% of the measured endpoint, to be decided real-time by a TIE subcommittee.

Table 1. Site List

Proposed Sites	Latitude	Longitude	Water - Targeted Events Only	Reasons for selection
American River @ Discovery Park	38.60094	-121.5055	X	American R watershed. Proposed RMP core site
Sacramento R @ Rio Vista	38.16016	-121.68530	X	Sac River ds of Yolo Bypass, Sac R/DWSC confluence, and in-Delta contributions
Shag Slough @ Liberty Island Bridge	38.30667	-121.69278	X	Ecological significance of Cache/Prospect Slough complex. Ag and urban influences ds of Yolo Bypass. SVWQC site.

Basic Study Cost Breakdown

USGS total CUP monitoring costs[1] = $36,900

- 3 sites x 3 events = 9 samples x $2,400 (includes all current RMP analytes, data entry into NWIS, and sending data to ASC for upload to CEDEN, etc) = $21,600
- Sample collection, 3 events x $1,900 = $5,700
- Costs for 4 additional samples (to account for required QC) = $9,600

AHPL Toxicity costs[1] = $29,880

Basic toxicity testing total includes the following test species at 3 sites x 3 events:

- *C. dubia* 7-day survival & reproduction test: $1,160
- *P. promelas* (fathead minnow) 7-day test: $1,200
- *S. capricornutum* (algae) 4-day test: $960

The study does not include any costs for TIEs due to the inflexible nature of study costs associated with an SEP and detailed in a Stipulated Agreement. The Delta RMP SC could decide in advance to cover the costs of a Phase I TIE (max cost $6,600) if toxicity is detected at any of the SEP's targeted monitoring sites.

Study Description for Supplemental Environmental Project Funds

Study Budget

Delta Regional Monitoring Program (RMP)
Pesticides and Toxicity Project by the Aquatic Science Center (ASC)

Study Budget, Total	$155,000*
ASC Subcontractor Coordination Costs (10%) Subcontractor Costs[1,2]	$15,500 $139,500
ASC Oversight Cost* (3%)	$4,650*

*This cost will be paid for by the Discharger

Study Description

The Delta RMP is currently implementing the Low ("Bare Bones") level of monitoring described in the monitoring design. The goal of this study is to implement Delta RMP current use pesticide (CUP) monitoring at **4 additional sites** (see Table 1) in the Delta that are not currently funded fiscal year 16/17. The monitoring includes event-based sampling for five targeted events (n = 5/year): **2 Wet weather** - (1) 1st seasonal flush (Water Year), (2) Significant winter storm; **3 Dry weather** - (1) Early Spring, (2) Late spring/early summer irrigation season, (3) Late summer irrigation season. All samples will undergo the same chemical analyses and toxicity testing that is currently being implemented for the monthly CUP monitoring:

Test species (endpoints) are: (1) *Selenastrum capricornutum* (growth) (2) *Ceriodaphnia dubia* (survival and reproduction), and (3) *Pimephales promelas* (larval survival and growth). Chemical analysis includes: pesticide scan (USGS list of 153 pesticides), total suspended solids, dissolved organic carbon (DOC) and particulate organic carbon (POC), hardness, and dissolved copper analysis. Pesticide-focused Toxicity Identification Evaluations (TIEs) are conducted for a subset of samples with > 50% of the measured endpoint, to be decided real-time by a TIE subcommittee.

Table 1. Site List

Proposed Sites	Latitude	Longitude	Water - Targeted Events Only	Reasons for selection
American River @ Discovery Park	38.60094	-121.5055	X	American R watershed. Proposed RMP core site
Sacramento R @ Rio Vista	38.16016	-121.68530	X	Sac River ds of Yolo Bypass, Sac R/DWSC confluence, and in-Delta contributions
Shag Slough @ Liberty Island Bridge	38.30667	-121.69278	X	Ecological significance of Cache/Prospect Slough complex. Ag and urban influences ds of Yolo Bypass. SVWQC site.

Proposed Sites	Latitude	Longitude	Water - Targeted Events Only	Reasons for selection
Sacramento R @ Veteran's Bridge	38.67460	-121.62817	X	Key inflow: Sac R upstream of Sacramento urban area

Basic Study Cost Breakdown

USGS total CUP monitoring costs[1] = $71,900

- 4 sites x 5 events = 20 samples x $2,400 (includes all current RMP analytes, data entry into NWIS, and sending data to ASC for upload to CEDEN, etc) = $48,000
- Sample collection, 5 events x $1,900 = $9,500
- Costs for 6 additional samples (to account for required QC) = $14,400

AHPL Toxicity costs[1] = $66,400

Basic toxicity testing total includes the following test species at 4 sites x 5 events:

- *C. dubia* 7-day survival & reproduction test: $1,160
- *P. promelas* (fathead minnow) 7-day test: $1,200
- *S. capricornutum* (algae) 4-day test: $960

The study does not include any costs for TIEs due to the inflexible nature of study costs associated with an SEP and detailed in a Stipulated Agreement. The Delta RMP SC could decide in advance to cover the costs of a Phase I TIE (max cost $6,600) if toxicity is detected at any of the SEP's targeted monitoring sites.

Study Description for

Supplemental Environmental Project Funds

Study Budget

Delta Regional Monitoring Program (RMP)
High Frequency Mapping Campaigns by USGS

Study Budget, Total	$105,000-178,500*
ASC Subcontractor Coordination Costs (5%) Subcontractor Costs[1]	$5,000-8,500 $100,000-$170,000
ASC Oversight Cost (3%)	$3,000-5,100*

*This cost will be paid for by the Discharger

The range of costs presented is because the project is scalable. The cost depends on the number of water cruises and locations monitored.

PROPOSAL: Assessing spatial variability of nutrients and related water quality constituents in the Delta: High frequency mapping campaigns

RESEARCHERS: Bryan Downing, Brian Bergamaschi, Tamara Kraus (USGS)

SUMMARY: This proposal is to document the variability of nutrients and related water quality parameters at high spatial resolution in the North Delta, Central Delta, and the Western Delta out to Suisun Bay. Measurement will include nitrate, ammonium, phosphate, temperature, conductivity, dissolved oxygen, chlorophyll, blue-green algal pigments, particle size and others. Data-collection cruises will be conducted under three different flow/export conditions (~4 days for each flow scenario), spaced approximately seasonally.

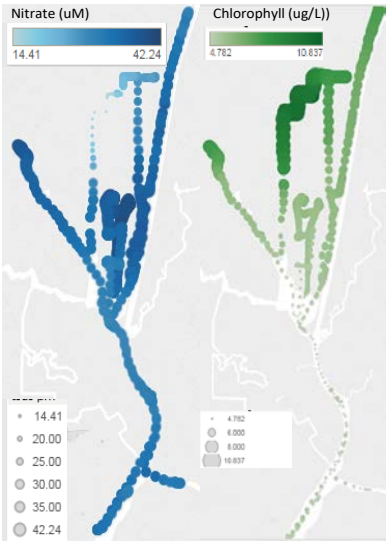


Figure 1. Maps of nitrate (left) and chlorophyll in the North Delta. Both size and color correspond to measured value.

PROBLEM: Monitoring stations and research sampling cruises in the Delta and Estuary are typically limited by the necessity to make measurements in a small number of well-mixed channels in the interest of collecting "representative" data and samples. Further, data collection is often conducted at locations occupied by historical data-collection efforts to

[1] Subcontractor costs are approximate until finalized

preserve comparability. The result is that we know little about the spatial variability of important water quality parameters in the Delta, and do not know how they vary under different flow and export conditions except through models. Also, historical station locations may no longer be representative as conditions may have changed due to variation in sources and changes in flow patterns. Spatial data will be highly useful for determining future monitoring locations.

APPROACH: The approach is to make high frequency (1/sec) measurements from a high-speed boat across broad areas of the Delta. This is made possible through the recent development of a boat-mounted flow-through sampling system that can be operated at high speeds (~20 mph), permitting rapid collection of high-quality measurements over large regions, within the context of a single tide. The resulting data is then mapped to the simultaneously-collected geopositional data (GPS) to generate maps with high spatial resolution (see figure). On-board instruments will include ones for nitrate, ammonium, temperature, conductivity, dissolved oxygen, chlorophyll-a, blue-green algal pigments, particle size and others. Discrete samples will be collected and enumerated for cyanobacteria and sent in for phosphate concentration measurements. Depending on availability of funds, these samples will also be sent in for total phytoplankton enumeration.

Study Description for Supplemental Environmental Project Funds

Study Budget

Delta Regional Monitoring Program (RMP)
Mercury Monitoring Implementation, Data Management, and Reporting by the Aquatic Science Center (ASC)

Study Budget, Total	$144,000*
ASC costs ASC Subcontractor Coordination Costs (0%) Subcontractor Costs	$144,000 $0 $0
ASC Oversight Cost (3%)	$0*

*This cost will be paid for by the Discharger

Study Description

The Delta RMP has applied for Prop 1 funding to implement a three-year mercury monitoring program. Prop 1 funding, if received, would cover the subcontract costs for field sampling and laboratory analysis. Project management, data management, and reporting will not be covered by the grant; yet, these tasks are critical for ensuring the project is completed, data are accessible, and information is available to Delta RMP committees. The estimated cost of these activities is $144,000. The specific tasks to be completed are listed below. Delta RMP funds in this amount were proposed as “cost-share” match in the Prop 1 proposal. No oversight or subcontractor coordination costs are needed for this task because all of the work will be performed by ASC and is part of a fully-scoped Prop 1 proposal.

Basic Study Cost Breakdown by Task

1. Project Management and Administration
    a. Establish and manage subcontract with Moss Landing Marine Laboratory
    b. Prepare for quarterly Steering Committee, quarterly Technical Advisory Committee meetings, and annual Mercury Workgroup meetings to convene stakeholders, regulators and scientific experts to provide feedback on project progress and direction.
    c. Prepare quarterly invoices to the funding entity
    d. Prepare quarterly progress reports to the funding entity
    e. Prepare annual reports to the funding entity
    f. Prepare Close-Out Summary Report accounting for all deliverables and expenses.

    This task will be completed with Cost Share Funds from the Delta RMP ($20,000 estimated).
2. – 4. Collection and Analysis of Fish, Water and Sediment
    a. To be completed by Subcontractor (Moss Landing Marine Lab)
3. Data Management

a. Perform QA/QC review on each annual dataset for mercury in water, sediment and fish samples. Prepare an annual Quality Assurance Report documenting QA/QC metrics and samples analyzed for each data set.
b. Upload water, sediment and fish collections and analytical data to CEDEN at end of each year following grant agreement execution.

The task will be completed with Cost Share Funds from the Delta RMP ($74,000 estimated).

6. Data Reporting
    a. Analyze fish data collected during FY 17-18, together with water, and fish data collected prior to the grant term in FY 16-17. Publish data and analyses in the 2018 Pulse of the Delta.
    b. Synthesize water, sediment and fish data collected during the first 2.5 years of the grant term (FY 17-18, FY 18-19, and the first half of FY 19-20), together with water and fish data collected prior to the grant term in FY 16-17. Statistical analyses of the data will be conducted by ASC using a software program such as R. Graphical representation of the data will be conducted using excel or R. Collaborate with Subcontractor to prepare a Final Report on results of mercury monitoring in water, sediment and fish tissue samples. A draft of the Final Report will be distributed to CDFW and Delta RMP stakeholders 90 days before the end of the grant term. The draft report will focus primarily on data collected during FY 16-19 (including the first two years of the grant term). Results from the final year of sampling will be included in the final report, which will be distributed prior to the end of the grant term. Additional analyses of the data are expected to be published in the 2020 Pulse of the Delta.
    c. Provide water and sediment data to the DWR Delta Hg modeling group.

The task will be completed with Cost Share Funds from the Delta RMP ($50,000 estimated).

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

RESOLUTION R5-2016-0009

SUPPLEMENTAL ENVIRONMENTAL PROJECTS PROGRAM TO BENEFIT THE DELTA REGIONAL MONITORING PROGRAM

The California Regional Water Quality Control Board, Central Valley Region (Central Valley Water Board) finds:

1. The Sacramento-San Joaquin Delta (Delta) is an important water supply for municipal, industrial and agricultural use for much of the State, and is a critical ecosystem for fish and wildlife, including many rare and endangered species.

2. The Delta Regional Monitoring Program (RMP) is a stakeholder-directed program formed to develop water quality data necessary for improving our understanding of Delta water quality issues. The goal of this effort is to better coordinate and design current and future monitoring activities in and around the Delta to create a cost effective approach for providing critically needed water quality information and analysis to better inform policy and regulatory decisions of the Central Valley Regional Water Quality Control Board and other Federal, State and local agencies and organizations.

3. The Central Valley Water Board is an agency of the State of California with the mission of preserving, protecting, enhancing, and restoring water quality within the Central Valley of California. In support of that mission, the Central Valley Water Board has the authority to enforce permit conditions and provisions of its Water Quality Control Plans by issuing Administrative Civil Liability Orders (ACL Orders).

4. Dischargers who wish to settle alleged water quality violations may offer to complete Supplemental Environmental Projects (SEPs) that offset the financial liability that may otherwise be imposed by the Central Valley Water Board; dischargers may fund SEPs in lieu of submitting payments to the State Water Resources Control Board's (State Water Board) Water Pollution Cleanup and Abatement Account and/or Waste Discharge Permit Fund. SEP settlements are memorialized in Stipulated ACL Orders.

5. The State Water Board has adopted a Water Quality Enforcement Policy (dated 17 November 2009) and a Statewide Policy on Supplemental Environmental Projects (SEP Policy) (dated 3 February 2009) that together regulate the use of SEPs statewide.

6. The SEP Policy defines SEPs as, " projects that enhance the beneficial uses of the waters of the State, that provide a benefit to the public at large and that, at the time they are included in the resolution of an ACL action, are not otherwise required of the discharger. SEPs are an adjunct to the State and Regional Water Quality Control Boards' enforcement program and are never the basis or reason for bringing an enforcement action."

7. As a general rule, the SEP Policy states that no settlements shall be approved by the State and Regional Water Boards that fund a SEP in an amount greater than 50 percent of the total adjusted monetary assessment against the discharger, absent compelling justification. The total adjusted monetary assessment is the total amount assessed, exclusive of a Regional Water Board's investigative and enforcement costs.

DELTA RMP PROPOSAL

8. Understanding the current conditions within the Delta (water quality and beneficial uses) and the potential impacts to those conditions is important in order to preserve and enhance the Delta and provide for corresponding regulatory and management decisions, which must be based upon sound science.

9. Currently, many agencies and organizations are conducting monitoring and data evaluation in the Delta, but there has been an overall lack of coordinated monitoring and data evaluation for a variety of reasons. The coordinated approach employed by the Delta RMP enhances the understanding of contaminant distribution in the Delta to better inform management and policy decisions.

10. The Delta RMP is an identified priority in the State Water Resource Control Board's and Central Valley Water Board's Delta Strategic Plan, and a Delta RMP is recommended in the Delta Plan adopted by the Delta Stewardship Council.

11. The Delta RMP is a stakeholder effort led by a steering committee. The steering committee consists of representatives from publicly owned treatment works, municipal storm water permittees, irrigated agriculture, coordinated monitoring groups, water supply, federal regulators, resource agencies, and staff from the Central Valley Water Board and State Water Board.

12. The Delta RMP has a monitoring design plan for pathogens, mercury, pesticides/toxicity, and nutrients. The monitoring design includes monitoring locations, constituents, and studies. The Delta RMP steering committee has approved plans for reporting data and findings to the public and how the RMP sampling will be coordinated with existing sampling efforts in the Delta by other entities. Annually, the steering committee establishes monitoring priorities, a detailed workplan, and budget.

13. The Delta RMP needs to secure sources of funding to provide timely and consistent data to make informed decisions. The exchange of current and future individual monitoring efforts to the Delta RMP and redirection of funding from those individual efforts has been the major source of funding for the Delta RMP. However, the Delta RMP is currently underfunded and only the minimum monitoring design is being implemented. Additional funding is required to implement the full monitoring design and address other management priorities in the future.

14. It is the intent of the Central Valley Water Board that all waste dischargers with the potential to impact Delta water quality will be encouraged to, and have the flexibility to, participate in the Delta RMP.

15. A viable source of funding for the RMP is from minimum mandatory penalties and discretionary administrative civil liabilities.

16. Currently, the Aquatic Science Center, a joint powers agency created on 1 July 2007 by a Joint Powers Agreement between the Bay Area Clean Water Agencies and the State Water Resources Control Board for the purpose of assisting with the efficient delivery of financial, scientific, monitoring, and information management support functions, is the agency that manages the Delta RMP. However, since the overseeing agency may be subject to change, this Resolution—as well as future iterations—will refer to the *Implementing Agency* to mean the agency managing the Delta RMP.

COMPLIANCE WITH THE ENFORCEMENT AND SEP POLICIES

17. In accordance with the Enforcement Policy, funding a SEP results in the permanent suspension of the portion of the liability in exchange for the performance of the project. To facilitate the Delta RMP SEP Program, the Central Valley Water Board shall consider "performance of the project" to mean actual payment of the amount agreed to by the discharger in the ACL Order to the Implementing Agency, along with a written acknowledgement and any other appropriate verification and enforceable representation to the Central Valley Water Board from the Implementing Agency that any SEP funds it receives from the discharger has been spent in accordance with the terms of the ACL Order that approves the SEP.

18. The Implementing Agency shall confirm the SEP funds received and expended in an annual report to the Central Valley Water Board, due by 31 January each year.

19. Upon receipt of SEP funds the Implementing Agency will publicly notice (e.g., on their website) and make clear that funds were received as part of a settlement agreement stemming from an enforcement action issued by the Central Valley Water Board.

20. The SEP Policy lays out the following general qualification criteria:

    a. The SEP shall only consist of measures that go above and beyond[1] the otherwise applicable obligations of the discharger and the Implementing Agency.

    b. The SEP shall directly benefit or study groundwater or surface water quality.

    c. A SEP shall never directly benefit, in a fiscal manner, a Water Board's functions, its members, staff, or family of members or staff.

[1] Currently Dischargers are reducing some of their receiving water monitoring requirements by contributing equivalent resources to the RMP. This reduction in individual monitoring consists of many parameters at one or several locations in the vicinity of discharge locations. Conversely, the Delta RMP is an intensive data collection effort at many locations in and around the Delta currently focusing on: pesticides/toxicity, pathogens, nutrients, and mercury. Dischargers are not individually required to conduct these broad studies. Additionally, any SEP funds would go towards assisting an already underfunded program (e.g., monitoring mercury in fish and water).

d. Unless express authorization is granted to a Regional Water Board by the State Water Board, a Regional Water Board may not manage settlement funds placed into an account for the purposes of completing a SEP.

21. Actions conducted by the Implementing Agency shall adhere to the above criteria and any other applicable criteria of the SEP Policy.

22. The SEP Policy states that, "there must be a nexus between the violation(s) and the SEP there must be a relationship between the nature or location of the violation and the nature or location of the proposed SEP. A nexus exists if the project remediates or reduces the probable overall environmental or public health impacts or risks to which the violation at issue contributes, or if the project is designed to reduce the likelihood that similar violations will occur in the future." For this initiative, the nexus will be evaluated on a case-by-case basis and requiring, at a minimum, the discharge to have the potential to negatively impact the water quality of the Delta.

23. The SEPs funded under the Delta RMP SEP Program are considered third-party SEPs, which means that the third-party entities that are paid to perform a SEP must be independent of both the discharger and the Central Valley Water Board.

24. By agreeing to participate in this project, the Implementing Agency agrees to subject all of its accounting and project-tracking materials related to the Delta RMP SEP Program to any audit at any time that one is deemed necessary by the Central Valley Water Board or by any other state or federal agency that requires such auditing.

25. It is the policy of the State Water Board that all ACL Settlements must be posted for a 30-day public comment period before they are finalized. In addition, this Resolution will be posted for 30 days to allow the public to provide input as to the merits of the Delta RMP SEP Program. As stated above, the Central Valley Water Board is committed to providing the public the opportunity to comment on revisions to the Delta RMP SEP Program when it is updated each year.

26. The Central Valley Water Board's approval of this Resolution is not considered subject to the provisions of the California Environmental Quality Act (CEQA) as it will not result in a direct or reasonably foreseeable indirect physical change in the environment and is not considered a "project." (Pub. Resources Code § 21065; Cal. Code Regs., tit 14, §§ 15060(c)(2),(3); 15378(a).) At the time Administrative Civil Liability Orders approving the funding of Delta RMP SEPs are approved, the Central Valley Water Board must consider whether CEQA applies to the issuance of the Board's Order, and whether additional CEQA work is required.

THEREFORE BE IT RESOLVED, the Central Valley Water Board, after considering the entire record, including written and oral testimony at the hearing:

1. Approves the 2015 Delta RMP SEP Program.

2. Directs Board staff to work with the Implementing Agency to publicize the Delta RMP SEP Program on the Central Valley Water Board's website, and to give serious consideration to

all proposals that would include these SEPs as a part of the settlement of a discharger's potential civil liability.

3. Instructs the Implementing Agency to report back to the Central Valley Water Board by 31 January of each year, providing information regarding the receipt and expenditure of SEP funds during the preceding calendar year. Copies of this report shall be available to all dischargers that have contributed to the Delta RMP in the prior year. The Implementing Agency shall also submit this report to the Division of Financial Assistance at the State Water Board under penalty of perjury, declaring that the funds submitted to the Implementing Agency have been expended during the preceding year on the Delta RMP SEP Program. Funds expended over multiple years will be reported on as many yearly reports as necessary until they are fully spent. These reports shall be considered a final post-project accounting of expenditures, as additional reporting on individual projects would be unduly onerous.

4. Dischargers that direct funds to the Implementing Agency for use in a SEP for the Delta RMP SEP Program will have an equivalent amount of administrative civil liability suspended at the time they make actual payment of the amount agreed to in the ACL Order to the Implementing Agency, provided that the ACL Order also states that the Central Valley Water Board is entitled to recover any funds that are not expended in accordance with the terms of the ACL Order.

I, PAMELA C. CREEDON, Executive Officer, do hereby certify the foregoing is a full, true, and correct copy of a Resolution adopted by the California Regional Water Quality Control Board, Central Valley Region on 19 February 2016.

Original Signed By

PAMELA C. CREEDON, Executive Officer

AQUATIC SCIENCE CENTER

To: Patrick Morris and Selina Cole
Central Valley Regional Water Quality Control Board

From: Philip Trowbridge, Manager
Delta Regional Monitoring Program

Date: August 9, 2016

Re: Administration of Supplemental Environmental Projects Conducted through the Delta Regional Monitoring Program

On February 19, 2016, the Central Valley Regional Water Quality Control Board approved the Delta Regional Monitoring Program (Delta RMP) to receive Supplemental Environmental Project (SEP) funds (Resolution R5-2016-009). The purpose of this memorandum is to outline the fees that will be charged for administering these funds and managing these projects. Further information about SEP funding can be found in the State Water Resources Control Board Policy on Supplemental Environmental Projects (February 3, 1990) (http://www.waterboards.ca.gov/rwqcb5/water_issues/enforcement/sep_policy_2009.pdf).

Program Administration Fees

There are two very different types of tasks associated with managing SEP funds: Oversight tasks and Project Development and Coordination tasks.

Oversight Tasks

Oversight tasks consist of fiscal management and basic project tracking and reporting. Based on precedent with other SEP funds administrators, the costs associated with the oversight of the SEP are not costs that should be considered part of the direct cost of the SEP for the purposes of determining the value of the SEP.

Proposed Fee: 3% of settlement amount, not part of the SEP

Specific Duties:

- Project management and Fiscal tracking/reporting
- Audit

Project Development and Coordination Tasks

Depending on the level of complexity, technical projects conducted through the Delta RMP may require additional project development and coordination to ensure that the data collected is accurate, complete, and compatible with program plans and designs. These tasks are integral to the project and should be funded as part of the SEP.

Proposed Fee: 0-10% of settlement amount depending on the complexity of the project, funded out of the SEP. For example, adding an additional station to the existing Monitoring Design and QAPP will require minimal development and coordination, but developing and managing a special study may require significant effort.

Specific Duties:

- Developing detailed proposals for projects to fit settlement
- Coordinating input and holding meetings of the Steering Committee and Technical Advisory Committee to review of projects and deliverables
- Coordinating with subcontractors for the SEP and other related projects
- Preparing and managing subcontracts
- Creating or updating quality assurance and program planning documents
- Resolving technical issues that arise during the course of the project
- Verifying that all laboratory results are provided by laboratory subcontractors in an acceptable format

Additional Tasks

Additional tasks such as technical report writing and quality assuring and uploading data to CEDEN can either be funded as part of the SEP scope of work or by the Delta RMP at the discretion of the Steering Committee.

Materials for Agenda Item 13

DATE: October 8, 2016

TO: Delta RMP Steering Committee

FROM: Patrick Morris, Selina Cole, and Philip Trowbridge

RE: Summary of SWAMP Contract Funds for FY16/17

Requested Action

Decide on how to utilize SWAMP Contract funds for toxicity testing before these funds expire on June 30, 2017.

Background

The Regional Water Board committed $467,000 in SWAMP Contract funds for the Delta RMP for FY 14/15 through 16/17 for toxicity analysis (4 species plus toxicity identification evaluations (TIEs)) by the UC Davis Aquatic Health Program Laboratory (AHPL). Due to delays in starting pesticide and toxicity monitoring, no contract resources were used in FY14/15 so the FY14/15 allocation was rolled into FY 15/16. In addition, water toxicity using *Hyalella azteca* was not conducted in FY15/16, so the overall expenditures were less than budgeted. The total expenditure for FY14/15 through 15/16 was $212,855. Therefore the total available for FY16/17 is $254,145. (See Table 1).

The FY16/17 Detailed Workplan and Budget estimates that the total cost of toxicity testing and TIEs is expected to be $267,700. However, this budget assumed $40,000 for TIEs. Last year, the cost for TIEs was $6,555. If a similar number of TIEs are performed in FY16/17 as FY15/16, there would be $28,378 of SWAMP Contract funds left unused when the contract expires.

The purpose of this memo is to outline options to use all of the SWAMP Contract funds before the contract expires.

SWAMP Contract Constraints

The current SWAMP Contract end date is June 30, 2017. All samples must be submitted to the lab for analysis by that date. If all of the designated funding is not spent, there is the potential that future SWAMP Contract resources for the RMP could be reduced.

The constraints under the contract are that the funding must be for services involving TIEs or toxicity analyses using any or all of the four test species. The contract does not cover any non-services activities such as academic research or project development.

Options

1) No action option. If the toxicity sampling design does not change, up to $28,378 of SWAMP Contract funds will not be used, which may reduce the amount of SWAMP Contract funds available in future budget years (see Table 1). This option assumes 2 pesticide focused TIEs and 1 Phase 1 TIE.
2) Analyze samples for *Hyalella* toxicity from November 2016 through June 2017. Use the SWAMP funds for a full 12 months for toxicity by *Ceriodaphnia, Phimephales*, and *Selenastrum* and TIEs for these species at 5 sites and add *Hyalella* monitoring at 5 sites for 8 months starting in November. Assuming 2 pesticide focused TIEs and 1 Phase 1 TIE, this proposal would use up all the SWAMP funds by June 30, 2017 (see Table 1). Approximately $1,300 of Delta RMP funds would be required to augment the AHPL contract to pay for all the analyses. The amount of Delta RMP funds needed could increase if more TIEs are performed than were assumed.
3) Other options related to toxicity method validation are being researched and will be discussed at the Steering Committee meeting.
4) Any additional options proposed by Steering Committee members.

Table 1. Summary of Expended, Available, and Projected Toxicity Monitoring Costs for the Delta RMP

SWAMP 14/15 + 15/16 Allocation = $ 267,000
SWAMP 16/17 Allocation = $ 200,000

15/16 Current Use Pesticicide Monitoring: Toxicity at Baseline Sites

Parameter	Field QA	15/16 Cost	Total SWAMP Cost
Ceriodaphnia 7-day Test	59	$ 1,150	$ 67,850
Phimephales 7-day Test	65	$ 1,185	$ 77,025
Selenastrum Test	65	$ 945	$ 61,425
Hyallela 4-day Survival	0	$ 660	$ -
Phase I TIE - Fresh Water	1	$ 6,555	$ 6,555
		15/16 Total =	**$ 212,855**

Total Available for 16/17 = $ 254,145

16/17 Current Use Pesticicide Monitoring: Toxicity at Baseline Sites (NO ACTION OPTION)

Parameter	# Sites	Samples/Year	Field QA	16/17 Cost	Total SWAMP Cost
Ceriodaphnia 7-day Test	5	12	3	$ 1,210	$ 76,230
Phimephales 7-day Test	5	12	3	$ 1,245	$ 78,435
Selenastrum Test	5	12	3	$ 995	$ 62,685
Hyalella 4-day Survival	5	0	0	$ 690	$ -
TIE - Pesticide Focused*	1	2	0	$ 766	$ 1,532
Phase I TIE - Fresh Water*	1	1	0	$ 6,885	$ 6,885
*TIE funds capped at $40K (by RMP)				**16/17 Total =**	**$ 225,767**

Total Remaining = $28,378

16/17 Current Use Pesticicide Monitoring: Toxicity at Baseline Sites (HYALELLA OPTION)

Parameter	# Sites	Samples/Year	Field QA	16/17 Cost	Total SWAMP Cost
Ceriodaphnia 7-day Test	5	12	3	$ 1,210	$ 76,230
Phimephales 7-day Test	5	12	3	$ 1,245	$ 78,435
Selenastrum Test	5	12	3	$ 995	$ 62,685
Hyalella 4-day Survival	5	8	3	$ 690	$ 29,670
TIE - Pesticide Focused*	1	2	0	$ 766	$ 1,532
Phase I TIE - Fresh Water*	1	1	0	$ 6,885	$ 6,885
*TIE funds capped at $40K (by RMP)				**16/17 Total =**	**$ 255,437**

Total Remaining = -$1,292

Supplemental Materials

AQUATIC SCIENCE CENTER

DATE: September 26, 2016

TO: Delta RMP Steering Committee

THROUGH: Delta RMP Finance Committee

FROM: Philip Trowbridge, Program Manager

RE: Summary of Delta RMP Financials – period ending 8/31/16

The purpose of this memorandum is to provide an update of budgets and expenses for all open RMP budget years (FY14/15, FY15/16 and FY16/17) and the balance of Program Reserve funds. All of the presented values are current through 8/31/16.

Delta RMP FY14/15 Budget

Revenue

All of the expected contributions for the FY14/15 Delta RMP budget have been received.

Expenses

The FY14/15 budget was originally $251,000 but was adjusted down to $210,000 by the Steering Committee. At the June 16, 2015 meeting, the Steering Committee voted to move funds that had been allocated for Current Use Pesticide Monitoring ($41,000) in the FY14/15 budget to the FY15/16 budget.

Expenses to date are within budget. All of the tasks except for the Nutrient Synthesis have been completed and associated funds are nearly exhausted. Most remaining funds in this budget are for the USGS subcontract for the High-Frequency Nutrient Sensor Synthesis Report. Any unused funds in this budget will be unencumbered in January 2017.

Figure 1 shows a comparison of expenses to budget by category. For more detailed information on budgets and expenses by line item, please refer to Table 1.

Delta RMP FY15/16 Budget

Revenue

A total of $1,097,382 in the contributions for the FY15/16 Delta RMP budget has been received or committed as in-kind resources (SWAMP contract). The last remaining invoice to be paid is

$35,000 from the Sacramento Valley Water Quality Coalition. The SC already approved moving $100,000 and $84,444 of the excess revenue in FY15/16 to the FY16/17 budget and the reserve, respectively. See Table 2 for a breakdown of contributions for FY15/16.

Expenses

Approximately 62% of the budget has been spent ($563,783 of the $912,938 budget). The tasks for Program Management, Governance, Quality Assurance, Communications, and Pathogens Year 1 Data Management are complete. Any unused funds in the budgets for these tasks will be unencumbered in January 2017. Most of the remaining funds are for subcontractors for Pesticide/Toxicity and Pathogens monitoring. The remaining deliverables to be completed include: data management associated with pathogens, pesticides, and toxicity analyses; a data report for the first year of pesticide/toxicity monitoring; and a nutrient workshop and summary report for future nutrient monitoring. We anticipate being able to finish these deliverables on budget.

For the Nutrients Synthesis task, the original budget was $30,000 for ASC labor and $20,000 for subcontractors. Fewer subcontractors and more ASC time are needed for the task. Therefore, we expect the final breakdown between labor and subcontractors to be $40,000 and $10,000, respectively.

Figure 2 shows a comparison of expenses to budget by category. For more detailed information on budgets and expenses by line item, please refer to Table 3.

Delta RMP FY16/17 Budget

Revenue

In April, the Steering Committee approved the revenue for FY16/17 of $1,056,053. ASC has invoiced most participants based on the approved revenue. A total of $720,050 (68%) has been received or committed as in-kind resources (SWAMP contract), $278,003 has been invoiced but not paid, and $58,000 is still being negotiated. See Figure 4 and Table 4 for a breakdown of contributions for FY16/17.

At this time, there is some uncertainty regarding the expected revenue from the City of Modesto and the Port of Stockton. Based on discussions with the Regional Board, it was assumed that the contributions from these two stormwater agencies would be $38,000. Therefore, this amount was included in the FY16/17 Detailed Workplan revenue table as a placeholder. The actual revenue from these two participants is still being negotiated and will be reported after negotiations are complete. If less than the approved revenue needed for the Detailed Workplan is received, then reserve funds will need to be added to the FY16/17 budget to cover the planned FY16/17 expenses.

Expenses

Approximately 9% of the budget has been spent ($96,401 of the $1,043,030 budget). Program Planning work (Task 1A) started before July 1 in order to prepare a proposal for Prop 1 funding for mercury monitoring ($600k). Preparing the proposal cost approximately $5,000. Some of the funds for Task 6D (Pesticide/Toxicity Data Management) were used to finish up formatting and uploading pathogens data from the first year of monitoring. These charges (~$3,000) would be more appropriately charged to Task 5A in the FY15/16 budget (Pathogens Data Management). The work was charged to this line instead because the budget for FY15/16 Task 5A had been exhausted due to the extra time needed to deal with hand-written data submittals from the laboratories. Despite the extra work needed to wrap up the pathogens dataset, we expect to complete the pesticide data management work within the given budget. Most of the deliverables for the year are yet to be completed. It is too early to tell whether expenses are tracking below or above budgets for each task.

Figure 3 shows a comparison of expenses to budget by category. For more detailed information on budgets and expenses by line item, please refer to Table 5.

RESERVE FUNDS

Table 6 shows a running list of deposits and withdrawals into the Undesignated Funds Reserve. The current balance of undesignated funds is $116,347.

No withdrawals or deposits to the Reserve are requested at this time.

Figures and Tables

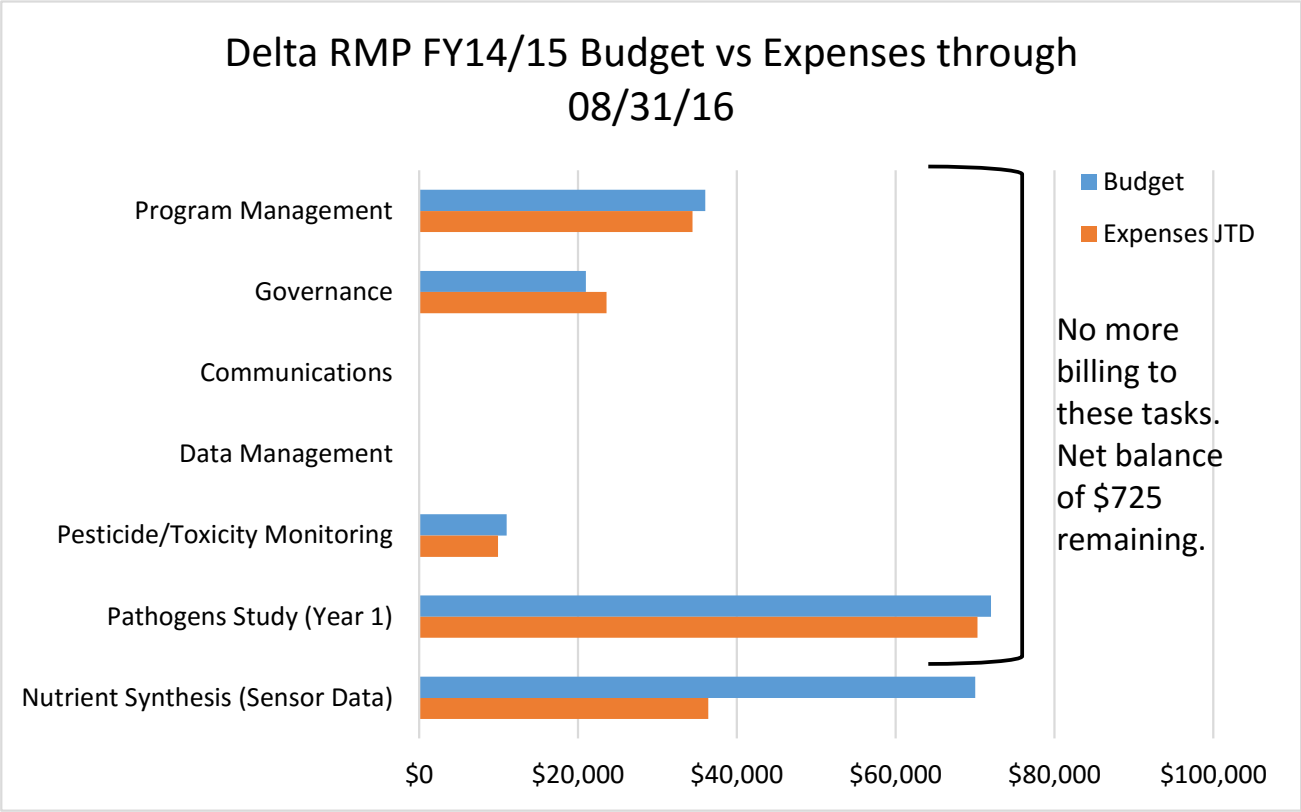


Figure 1: Delta RMP FY14/15 Budget. Budget and expenses from 1/1/15 through 8/31/16 by task.

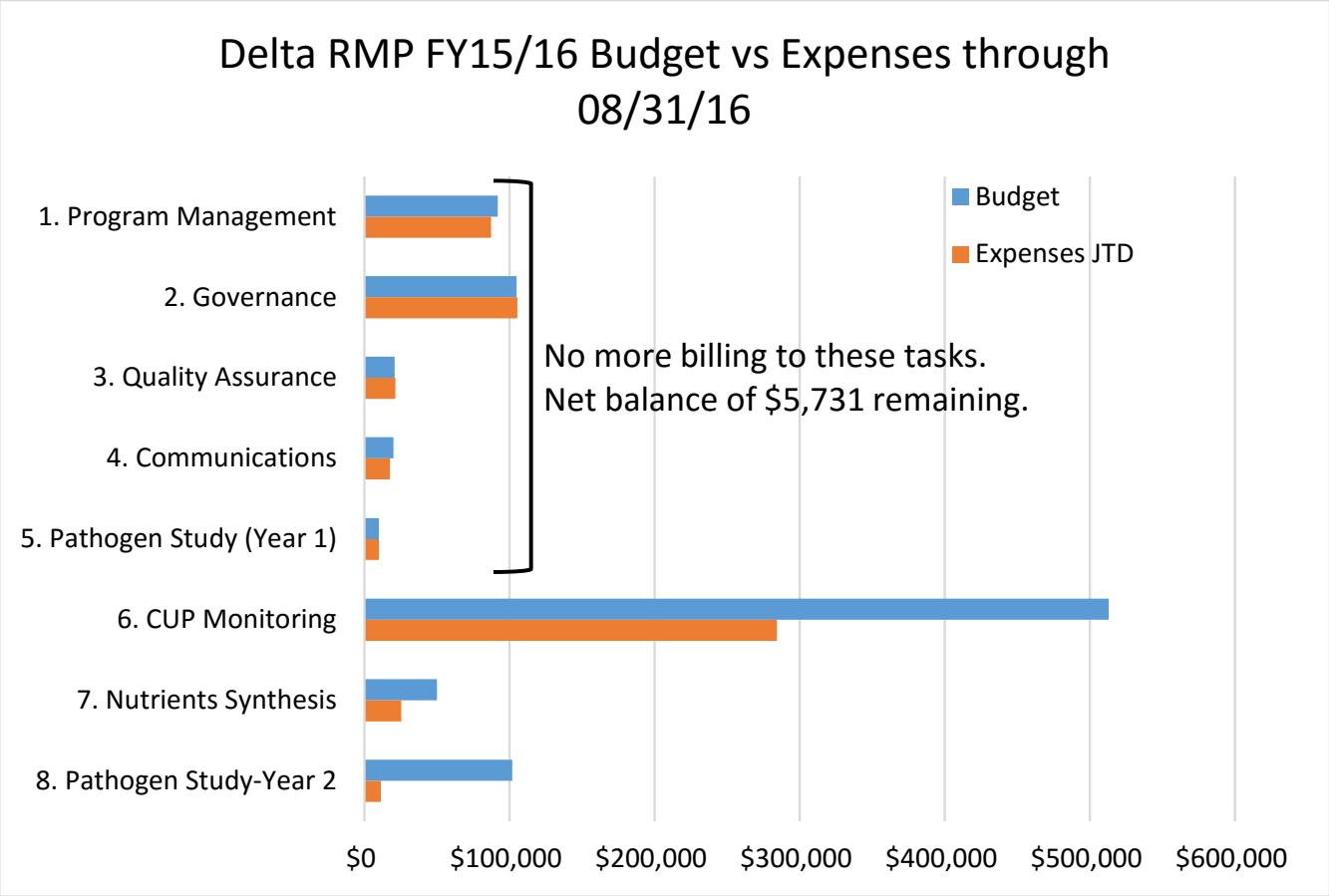


Figure 2: Delta RMP FY15/16 Budget. Budget and expenses from 7/1/15 through 8/31/16 by task.

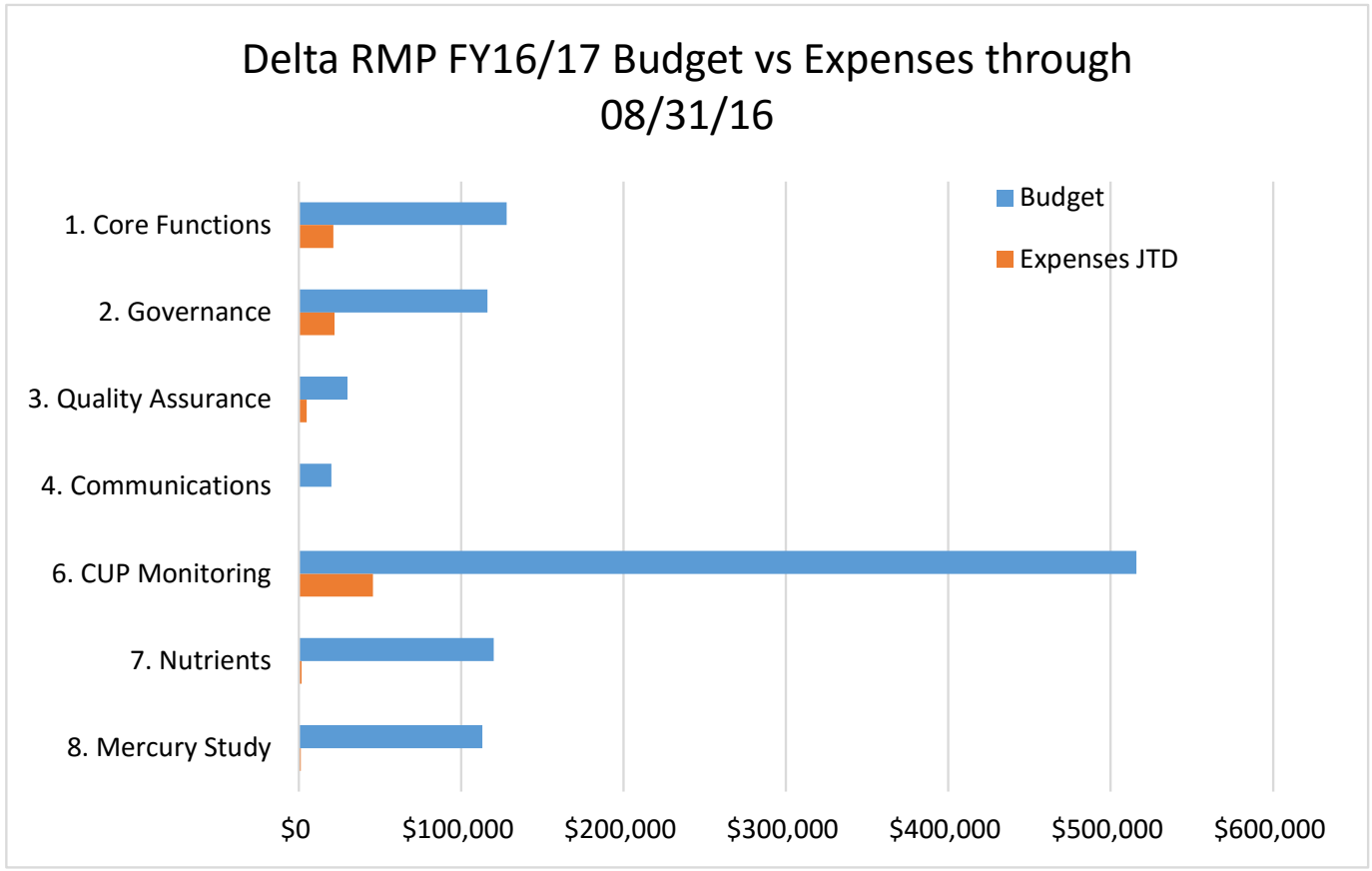


Figure 3: Delta RMP FY16/17 Budget. Budget and expenses from 5/1/16 through 8/31/16 by task.

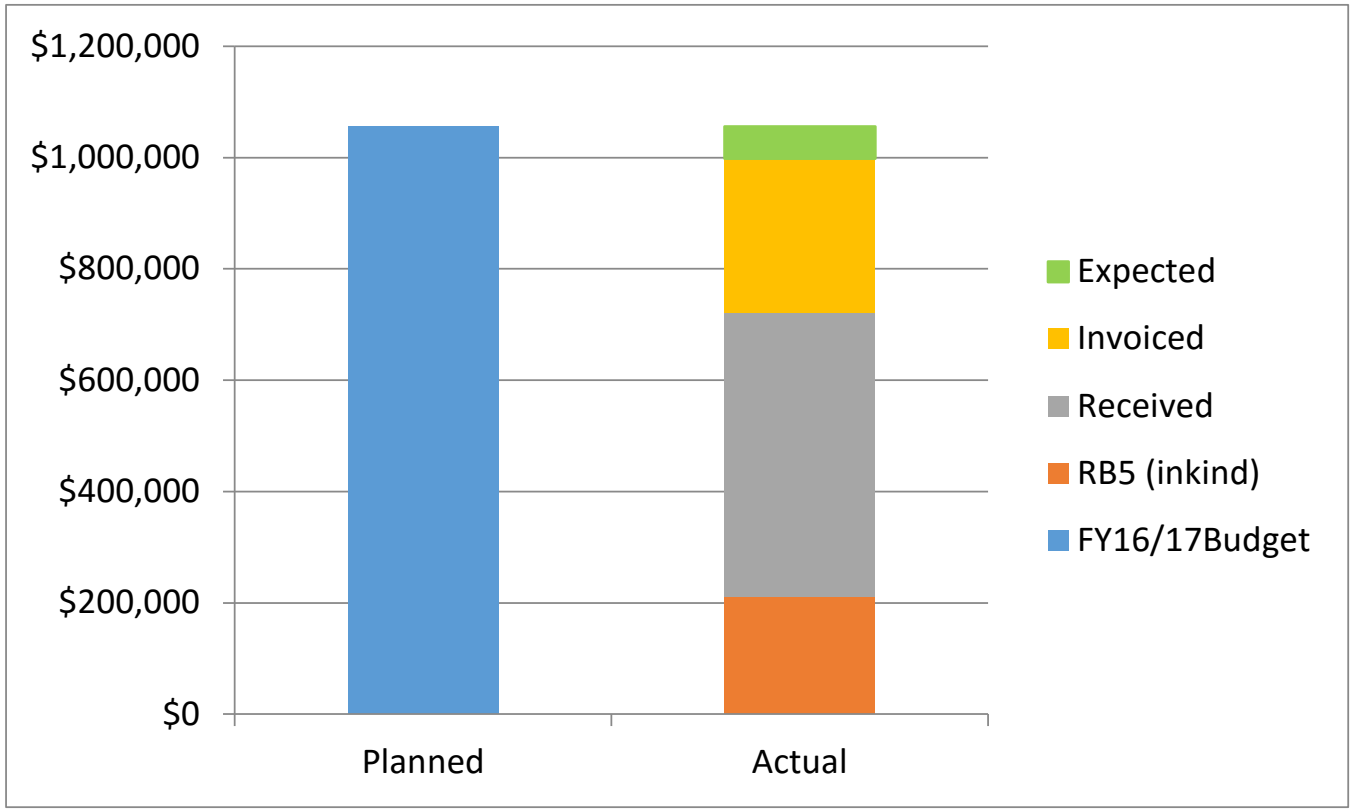


Figure 4: Delta RMP Revenue for FY16/17. Planned revenue versus revenue received to date.

Table 1: Delta RMP FY14/15 Budget. Budget and expenses from 1/1/15 through 8/31/16 by line item.

Task	Original Budget	Budget Adjustment	Final Budget	Expenses Through Last Report	New Expenses Since Last Report	Staff and Subcontractors Billing Since Last Report	Work Summary For This Report	Total Expenses To Date	Funds Remaining
Program Management	$36,000		$36,000	$34,393	$0	task closed		$34,393	$1,607
Governance	$21,000		$21,000	$23,600	$0	task closed		$23,600	-$2,600
Communications	$0		$0	$0	$0			$0	$0
Data Management	$0		$0	$0	$0			$0	$0
Pesticide/Toxicity Montioring									
Logistics and Coordination	$11,000		$11,000	$9,932	$0	task closed		$9,932	$1,068
Field Sampling and Pesticide Lab	$41,000	-$41,000	$0	$0	$0		Funds Moved to FY15/16 budget	$0	$0
Toxicity/TIE Lab	$0		$0	$0	$0			$0	$0
Pathogens Study (Year 1)	$72,000		$72,000	*$70,265	$1,085	Lab subcontracts	Analyses of monthly samples for pathogens. Work is complete. No more expenses expected.	$71,350	$650
Nutrient Synthesis (Sensor Data)	$70,000		$70,000	$36,401	$0	USGS subcontract		$36,401	$33,599
Total	**$251,000**	**-$41,000**	**$210,000**	**$174,590**	**$1,085**			**$175,675**	**$34,325**

*This value is was adjusted up by $680 from last financial report. We expected a higher amount of credits from the labs than were actually received.

Table 2: Delta RMP FY15/16 Revenue (invoiced, received or reserve funds) through 8/31/16 by participant group.

	In-Kind	Invoiced	Received	Total
ILRP		$35,000	$113,780	$148,780
MS4 Phase 1			$158,200	$158,200
MS4 Phase 2			$169,999	$169,999
POTW			$209,754	$209,754
SFCWA			$100,000	$100,000
RB5	$267,000			$267,000
Carryover from FY14/15			$41,000	$41,000
Water Board Funds for Comms Plan			$17,649	$17,649
Reserve funds allocated for Pathogen trigger study (SC approved 4/25/16)			$20,000	$20,000
Total	$267,000	$35,000	$830,382	$1,132,382
Total Budgeted Expense	$267,000		$645,938	$912,938
Project Surplus/Deficit for In-Kind and Received Resources*	$0		$184,444	
Transfer of SFCWA funds to reserve and then FY16/17 budget (SC approved 4/25/16)			($100,000)	
Surplus as of July 1, 2016	$0		$84,444	
Surplus transferred to reserve (SC approved 7/20/16)			($84,444)	

*Surplus calculation does not include invoiced funds, only received.

In-Kind Revenue = SWAMP contract funds or other in-kind services that can only be used for a defined purpose
Received Revenue = Funds received by ASC
Invoiced Revenue = Funds for which ASC has sent invoices to participants but has not yet received
Expected Revenue = Funds that are expected but are not formally committed through an invoice or contract.

Table 3: Delta RMP FY15/16 Budget. Budget and cumulative expenses through 8/31/16 by line item, with detailed report for expenses for the period since the last report (7/1/16 to 8/31/16).

Task	Subtask	Budget	Expenses Through Last Report	New Expenses Since Last Report	Staff and Subcontractors Billing Since Last Report	Work Summary for This Report	Total Expenses To Date	Funds Remaining
1. Program Management	A. Program Planning	$45,000	$44,832	$0			$44,832	$168
	B. Contract and Financial Management	$47,000	$42,479	$143	Amy Franz (0.5 hr this quarter)	These charges reflect data management input on the July financial report. Other staff time on this deliverable was billed to the FY16/17 budget (Task 1B).	$42,622	$4,378
2. Governance	A. SC meetings	$45,900	$45,678	$0			$45,678	$222
	B. TAC meetings	$59,000	$59,220	$535	Meg Sedlak (3.5 hrs)	Worked with labs to have them submit data in the correct electronic format and to submit QA data.	$59,755	($755)
3. Quality Assurance	A. Quality Assurance System	$10,000	$11,507	$0			$11,507	($1,507)
	B. Technical Oversight and Coordination	$11,000	$10,060	($237)	Micha Salomon (-2.5 Hrs)	Credit for incorrect billing to this task. This credit was shown on the previous report so there is no change in the balance (except round off). The correction was made on a the July invoice which is why it shows up on this report.	$10,056	$944
4. Communications	A. Communications Plan	$16,000	$16,000	$0	Closed		$16,000	$0
	B. Communications Product	$4,000	$1,649	$0	Closed		$1,649	$2,351
5. Pathogen Study (Year 1)	A. Data Management	$10,000	$9,984	$87	Patrick Kim (2 hours)	Review and formatting of pathogen data for CEDEN uploads.	$10,070	($70)
6. CUP Monitoring	B. Pesticide Laboratory Work	$189,208	$58,889	$0	USGS	No invoices from USGS were paid during this period.	$58,889	$130,319
	C. Toxicity Laboratory Work	$287,830	$212,855	$0	UCD AHPL	All monthly toxicity testing for the year is complete. All the costs for the year were covered by the SWAMP contract. The total cost for the year ending 6/30/16 was $212,855. The cost covered monthly results for 3 toxicity tests (not including Hyallela) and one TIE. The balance shown is a combination of unused SWAMP funds that will be rolled over to FY16/17 ($54,145) and unused RMP funds that can be unencumbered to the Reserve ($20,830).	$212,855	$74,975
	D. Data Management	$21,000	$8,537	$3,566	Don Yee (2.5 hrs), Amy Franz (21.75 hrs), John Ross (0.5 hr), Michael Weaver (0.5 hr), Adam Wong (8.75 hrs), Jennifer Sun (0.5 hr)	Reviewed and formated raw UCD toxicity and USGS pesticide data.to get it ready for CEDEN uploads. Held multiple coordination calls with RB5 and SWAMP to resolve data issues. Initiated QA/QC review of the data.	$12,103	$8,897

Task	Subtask	Budget	Expenses Through Last Report	New Expenses Since Last Report	Staff and Subcontractors Billing Since Last Report	Work Summary for This Report	Total Expenses To Date	Funds Remaining
	E. Reporting	$15,000	$0	$611	Phil Trowbridge (.25 hr), Don Yee (1 hr), Ila Shimabuku (5.5 hrs)	Began work on CUP field sampling report for TAC meeting (9/20/16).	$611	$14,389
7. Nutrients Synthesis	A. Synthesis Report - Monitoring Data Gaps	$50,000	$16,129	$9,500	Phil Trowbridge (4.5 hrs), Thomas Jabusch (70 hrs)	Developed workshop agenda and planned logistics. Conducted a survey of participants. Scheduled and held interviews with Joe Domagalski, Marianne Guerrin, Sam Harader, Peggy Lehman, Janis Cooke, S. Philippart, NASA, etc. Updated inventory of nutrient monitoring in the Delta. Reviewed recent synthesis reports. Started drafting summary report.	$25,629	$24,371
8. Pathogen Study-Year 2	A. Monthly Pathogen Sampling	$72,000	$0	$10,360	Lab subcontracts	Invoices for laboratory analyses of pathogens.	$10,360	$61,640
	B. Data Management	$10,000	$1,140	$26	Amy Franz (0.25 hr)	Assistance with electronic data deliverable templates.	$1,165	$8,835
	C. Pathogen Followup Trigger Study	$20,000	$0	$0			$0	$20,000
	TOTAL	**$912,938**	**$538,959**	**$24,591**	**119.5 Hours**		**$563,783**	**$349,155**

Item 4. Communications. Funded by $20,000 from the Water Board contract with ASC. This contract was closed because it was unable to be extended; $2,351 was returned to Water Board.
Item 6C. Estimated expenditures on the SWAMP contract for toxicity analyses were based on unit costs, the number of samples collected to date, and discussions with RB5 staff.

Table 4: Delta RMP FY16/17 Revenue (expected, invoiced, received or reserve funds) through 8/31/16 by participant group

Participant	In-Kind	Expected	Invoiced	Received	Total
ILRP				$148,780	$148,780
MS4 Phase 1		$38,000	$100,000	$58,200	$196,200
MS4 Phase 2		$20,000	$45,000	$124,999	$189,999
POTW			$133,033	$76,751	$209,754
SFCWA					$0
RB5 (in-kind)	$211,320				$211,320
Reserve				$100,000	$100,000
Total	$211,320	$58,000	$278,003	$508,730	$1,056,053

In-Kind Revenue = SWAMP contract funds or other in-kind services that can only be used for a defined purpose
Received Revenue = Funds received by ASC
Invoiced Revenue = Funds for which ASC has sent invoices to participants but has not yet received
Expected Revenue = Funds that are expected but are not formally committed through an invoice or contract.

The $100,000 contribution from Reserve was the SFCWA contribution in March 2016, which was originally credited to the FY15/16 budget, transferred to Reserve, and then re-allocated to the FY16/17 budget.

Table 5: Delta RMP FY16/17 Budget. Budget and cumulative expenses through 8/31/16 by line item, with detailed report for expenses for the period since the last report (5/1/16 to 8/31/16).

Task	Subtask	Budget	Expenses Through Last Report	New Expenses Since Last Report	Staff and Subcontractors Billing Since Last Report	Work Summary For This Report	Total Expenses To Date	Funds Remaining
1. Core Functions	A. Program Planning	$76,000	$0	$15,609	Phil Trowbridge (9 hrs this quarter), Meg Sedlak (32.25 hrs), Thomas Jabusch (27 hrs), Amy Franz (2.5 hrs), Micha Salomon (7 hrs), Jennifer Sun (61 hrs)	Submitted Prop 1 proposal for $600k for mercury monitoring (work completed in June in order to meet deadline). Completed Program Charter. Gathered and compiled information for Multi-Year Plan (budget estimates, upcoming regulatory decisions). Provided some coordination for the External Review and attended the meeting. Fielded and responded to calls from external stakeholders. Tracked deliverables and maintained "stoplight" reports.	$15,609	$60,391
	B. Contract and Financial Management	$52,000	$0	$5,668	Phil Trowbridge (8.75 hrs), Meg Sedlak (5.75 hrs), Meredith Lofthouse (19 hrs), Lawrence Leung (2 hrs), Frank Leung (12 hrs)	Managed existing contracts and developed new contracts with Regional San, County of Sacramento, and nutrient synthesis contractors. Scoped tasks and budgets for SEP with RB5 staff. Prepared quarterly financial report for SC and Finance Subcommittee. Reviewed and processed invoices and tracked expenses by task.	$5,668	$46,333
2. Governance	A. SC meetings	$51,300	$0	$16,693	Thomas Jabusch (36 hrs), Meg Sedlak (49.5 hrs), Phil Trowbridge (15 hrs), Brock Bernstein (10.75 hrs)	Held one SC meeting on 7/20/16. Prepared a large agenda package (129 pp.), coordinating with multiple document authors and presenters. Had pre- and post-meeting calls with many SC members and the co-chairs. Prepared a meeting summary, action items list, and Record of Decision following the meeting. Scheduled and held one Coordinating Committee meeting on 8/16/16. Scheduled and held one followup call with TAC co-chairs to communicate results of the SC meeting. Expenses this period also reflect invoice from Brock Berstein for facilitation services.	$16,693	$34,607
	B. TAC meetings	$64,800	$0	$5,200	Thomas Jabusch (7 hrs), Meg Sedlak (4.5 hrs), Phil Trowbridge (5 hrs), McCord Environmental (11.5 hrs)	Completed meeting summary from 6/14/16 TAC meeting. Held follow-up calls with TAC chairs to plan pesticide priortization item for next meeting. Developed agenda and lined up presenters for 9/20/16 TAC meeting. Responded to requests to schedule another Nutrients Subocommittee meeting by providing detailed timeline for all nutrient workshop and synthesis activities already planned for the fall. Expenses this period also reflect invoice from Stephen McCord for participating in SC meeting, coordinating TAC review and approval of QAPP, participating in External Review planning, and addressing QAPP revisions about mercury water sampling methods.	$5,200	$59,600

Task	Subtask	Budget	Expenses Through Last Report	New Expenses Since Last Report	Staff and Subcontractors Billing Since Last Report	Work Summary For This Report	Total Expenses To Date	Funds Remaining
3. Quality Assurance	A. Quality Assurance System	$15,000	$0	$4,299	Thomas Jabusch (24 hrs), Amy Franz (2.5 hrs), John Ross (8 hrs), Micha Salomon (2 hrs)	Completed QAPP revisions for SC review. Added amendments to the QAPP for a revised Hg sampling method for water and protocol for collecting hardness data so the data could be used by ILRP coalitions. Obtained State Board and SWAMP Quality Assurance Officer approvals. Gathered final signatures.	$4,299	$10,701
	B. Technical Oversight and Coordination	$15,000	$0	$376	Thomas Jabusch (3 hrs)	Coordination with MPSL and SWAMP regarding mercury sampling methods initiation of mercury sampling.	$376	$14,624
4. Communications	A. Factsheet	$5,000	$0	$0			$0	$5,000
	B. Workshops on Technical Issues	$15,000	$0	$0			$0	$15,000
6. CUP Monitoring	B. Pesticide Laboratory Work	$190,830	$0	$0	USGS	No invoices from USGS were paid during this period.	$0	$190,830
	C. Toxicity Laboratory Work	$267,700	$0	$41,400	UCD AHPL	The budget shown assumes $211,320 in SWAMP funds and $56,320 in Delta RMP funds. There are actually $254,145 of SWAMP funds available for use by 6/30/17.	$41,400	$226,300
	D. Data Management	$37,400	$0	$4,040	Donald Yee (11 hrs), Thomas Jabusch (3 hrs), Amy Franz (3.75 hrs), John Ross (2 hrs), Adam Wong (14 hrs)	Held coordination calls to deal with data flow issues between USGS, SWAMP, RB, Central Valley RDC and with providing monthly data to ILRP. Internal meetings on data management deliverables. Finished up formatting and upload of Year 1 pathogens data and prepared a QA Officer report summarizing those data. These charges (~$3,000) could be moved to FY15/16 Task 5A. The work was charged to this line instead because the budget for FY15/16 Task 5A had been exhausted due to the extra time needed to deal with undigitized data submittals from the laboratories. We expect to complete the pesticide data management work within the given budget.	$4,040	$33,360
	E. Reporting	$20,000	$0	$125	Thomas Jabusch (1 hr)	Report planning	$125	$19,875
7. Nutrients	A. Synthesis of Existing Data	$33,000	$0	$0			$0	$33,000
	B. Modeling	$50,000	$0	$1,614	Thomas Jabusch (11 hrs), Micha Salomon (2.5 hrs)	Developed scope for RMA modeling contract, performed GIS analyses to inform modeling work, and held didscussions with contractor.	$1,614	$48,386
	C. Statistics	$37,000	$0	$125	Thomas Jabusch (1 hr)	Began work on statistical analyses	$125	$36,875
8. Mercury Study	A Data collection	$90,000	$0	$0			$0	$90,000
	B. RMP Data Management	$14,500	$0	$0			$0	$14,500

Task	Subtask	Budget	Expenses Through Last Report	New Expenses Since Last Report	Staff and Subcontractors Billing Since Last Report	Work Summary For This Report	Total Expenses To Date	Funds Remaining
	C. ASC Oversight	$3,500	$0	$1,252	Thomas Jabusch (10 hrs)	Resolved mercury sampling method details and site locations. Field sampling began.	$1,252	$2,248
	D. Reporting	$5,000	$0	$0			$0	$5,000
	TOTAL	**$1,043,030**	**$0**	**$96,401**	**402.75 Hours**		**$96,401**	**$946,629**

Item 6C. Estimated expenditures on the SWAMP contract for toxicity analyses were based on unit costs, the number of samples collected to date, and discussions with RB5 staff.

Table 6: Delta RMP Undesignated Funds Reserve Ledger though 8/31/16.

Budget Year	Deposit or Withdrawal	Reserve Type	Authorized By	Date	Amount	Comment
FY14/15	Deposit	Undesignated Funds	Steering Committee	6/16/2015	$41,000	Release funds allocated for CUP monitoring in FY14/15 budget in order to re-allocate these funds into the FY1516 budget for CUP monitoring.
FY14/15	Deposit	Undesignated Funds		10/15/2016	$51,903	Extra revenue received in FY14/15. Actual revenue minus budgeted expenses for FY1415 (number is updated whenever budget is changed, date reflects most recent update).
FY15/16	Withdrawal	Undesignated Funds	Steering Committee	6/16/2015	($41,000)	Release funds allocated for CUP monitoring in FY14/15 budget in order to re-allocate these funds into the FY1516 budget for CUP monitoring.
FY15/16	Withdrawal	Undesignated Funds	Steering Committee	4/25/2016	($20,000)	Allocate funding to FY15/16 for possible pathogen trigger study (TBD).
FY15/16	Deposit	Undesignated Funds	Steering Committee	4/25/2016	$100,000	SC directed that SFCWA funding of $100K (contribution for FY15/16) be transferred to reserve.
FY 16/17	Withdrawal	Undesignated Funds	Steering Committee	4/25/2016	($100,000)	SC directed that $100K be withdrawn from the reserve to be reallocated as revenue for FY16/17. SFCWA contribution in March 2017 ($100K) will be allocated to FY17/18 revenue.
FY15/16	Deposit	Undesignated Funds	Steering Committee	7/20/2016	$84,444	SC approved that $84,444 be transferred from FY15/16 revenue to the reserve as undesignated funds.
TOTAL		Undesignated Funds			**$116,347**	

Delta RMP Action Items

Key to Status Colors:
Green indicates greater than 90 days until the deliverable is due.
Yellow indicates a deliverable is due within 90 days.
Red indicates a deliverable that is overdue.

	Primary	Meeting Date	Deliverable	Assigned To	Due Date	Status	Comments
1	TAC Action Items from 9/20/2016	09/20/16	Send Nutrient Sensor Synthesis Report including reconciled comments to TAC and SC	Joe Domagalski	10/11/16		
2	TAC Action Items from 9/20/2016	09/20/16	Modify the slides for the proposed process for pesticide prioritization before including them in the Oct 18 SC/TAC meeting agenda package or sending them to the Pesticides Subcommittee	Stephen McCord	10/04/16	Complete	
3	TAC Action Items from 9/20/2016	09/20/16	Send Doodle poll for first Pesticides Subcommittee Meeting	Thomas Jabusch	09/22/16	Complete	
4	TAC Action Items from 9/20/2016	09/20/16	Add a cover page to the toxicity report that explains how it fits into the overall reporting plan	Thomas Jabusch	12/06/16		
5	TAC Action Items from 9/20/2016	09/20/16	Send comments on management drivers table and Section 7B (TAC) of the approved Delta RMP Charter to Phil Trowbridge	TAC members	10/04/16	Complete	
6	TAC Action Items from 9/20/2016	09/20/16	Prepare slides about the TAC roles and responsibilities in the Charter and share them with the TAC for review before the October 18 meeting	Stephen McCord	10/17/16		
7	SC Action Items 07/20/2016	07/20/16	Send an invite to SC for January 26, 2017 meeting	Meg Sedlak	09/01/16	Complete	
8	SC Action Items 07/20/2016	07/20/16	Include page numbers in the agenda indicating location of agenda items, add blank pages between items in the agenda package.	Meg Sedlak	10/03/16	Complete	
9	SC Action Items 07/20/2016	07/20/16	Accept Charter track changes sent to SC and incorporate language modifications requested. Place final version in google drive under foundational documents.	Philip Trowbridge	08/17/16	Complete	
10	SC Action Items 07/20/2016	07/20/16	Send TAC the final version of the Charter before the 10/18/16 meeting.	Meg Sedlak	09/30/16	Complete	
11	SC Action Items 07/20/2016	07/20/16	ASC and Finance Subcommittee will meet to determine a way to provide the level of information requested. ASC will provide a cost estimate for any extra work associated with the increased reporting.	Meg Sedlak	10/03/16	Complete	This meeting took place immediately following the SC meeting. For future financial reports, ASC will use the same format as was developed for the Q2 report but also add the hours billed by each staff member for each task from the invoices.
12	SC Action Items 07/20/2016	07/20/16	Send out Management Driver table to SC and TAC	Meg Sedlak	09/30/16	Complete	
13	SC Action Items 07/20/2016	07/20/16	Add an agenda item to the October 18th Joint meeting agenda to discuss TAC comments on the Charter.	Meg Sedlak	09/30/16	Complete	
14	SC Action Items 07/20/2016	07/20/16	Table for TAC roster needs to be updated to reflect the composition indicated in the charter (e.g. resource agencies). Greg Gearheart and Jeff Stuart requested that they be added to the TAC mailing list as they seek to find TAC representatives.	Thomas Jabusch	09/30/16	Complete	
15	SC Action Items 07/20/2016	07/20/16	Develop a list of SEP projects that can be discussed at the MYP meeting.	Adam Laputz	09/30/16	Complete	

	Primary	Meeting Date	Deliverable	Assigned To	Due Date	Status	Comments
16	TAC Action Items from 6/14/2015	06/14/16	TAC needs to provide comments on QAPP by June 30th, 2016	TAC members	06/30/16	Complete	
17	TAC Action Items from 6/14/2016	06/14/16	ASC to confirm chlorophyll measurements conducted as part of FY16/17 Hg project are conducted using standardized procedures (e.g., SWAMP methods). TAC would like results to be comparable among other agencies.	Thomas Jabusch	07/01/16	Complete	
18	TAC Action Items from 6/14/2016	06/14/16	ASC to schedule meeting for the nutrient planning meeting (Day 1)	Thomas Jabusch	06/22/16	Complete	Doodle poll sent and possible dates identified.
19	TAC Action Items from 6/14/2016	06/14/16	Revise workshop description; send to nutrient subcommittee; send to TAC by July 1; and include in agenda package for SC meeting.	Thomas Jabusch	06/21/16	Complete	
20	TAC Action Items from 6/14/2016	06/14/16	For the FY16/17 nutrient synthesis task, Janis Cook requested that a clear explanation of EOF be included.	Thomas Jabusch	02/28/17		
21	TAC Action Items from 6/14/2016	06/14/16	TAC requested that minutes be more concise if possilbe	Thomas Jabusch	09/13/16	Complete	
22	TAC Action Items from 6/14/2016	06/14/16	Send out list of representatives on TAC and subcommittees	Thomas Jabusch	06/28/16	Complete	
23	TAC Action Items from 6/14/2016	06/14/16	Prepare a table of changes to the QAPP and send out the revised QAPP to TAC for approval by the end of the month. Indicate revision number (Rev 2).	Thomas Jabusch	06/21/16	Complete	
24	TAC Action Items from 6/14/2016	06/14/16	Co-chair report to SC should be prepared by 6/30/2016 and sent to TAC for comment. TAC comments need to be received by July 6th so the report can appear in SC agenda package.	Stephen McCord	06/22/16	Complete	
25	TAC Action Items from 6/14/2016	06/14/16	Post pdfs of presentations from June 14 meeting on TAC google drive	Thomas Jabusch	06/20/16	Complete	
26	SC Action Items 04/25/2016	04/25/16	SC members will provide ASC with comments on the Charter	Group	05/05/16	Complete	
27	SC Action Items 04/25/2016	04/25/16	Add an agenda item for the July SC meeting to discuss fees for FY17/18.	Meg Sedlak	07/20/16	Complete	On agenda
28	SC Action Items 04/25/2016	04/25/16	Work with Linda Dorn and Dave Tamayo to review the MOA to determine how they can adapt it to be a contract template for use by their respective organizations.	Philip Trowbridge	06/30/16	Complete	Sacramento County will extend the existing contract. Regional San will develop a multi-year MOU.
29	SC Action Items 04/25/2016	04/25/16	Val Connor will organize a Finance Subcommittee (members include Dalia Fadh, Mike Wackman, Linda Dorn, and Adam Laputz, only 3 needed for quorum). The Finance Committee will address questions such as: is the program as cost-efficient as possible?; what format and information is needed for the financial memorandums?; Are there places where the budget assumptions are flawed?; is the program on the right track financially?	Val Connor	07/20/16	Complete	
30	SC Action Items 04/25/2016	04/25/16	Incorporate edits from Debbie Webster and Linda Dorn on the December SC meeting minutes and then distribute the draft minutes back to the SC for review.	Thomas Jabusch	05/05/16	Complete	
31	SC Action Items 04/25/2016	04/25/16	Prepare a short summary of Delta RMP preliminary monitoring results/activities for the July SC agenda package.	Stephen McCord	07/20/16	Complete	
32	SC Action Items 04/25/2016	04/25/16	Revise the FY16/17 Detailed Workplan as follows: Table 1 to reflect the changes in FY16/17 revenue approved at the 4/25/16 meeting; and the last paragraph of the pathogens study description to reflect the allocation of funding for pathogens trigger studies to the FY15/16 budget.	Meg Sedlak	06/01/16	Complete	

	Primary	Meeting Date	Deliverable	Assigned To	Due Date	Status	Comments
33	SC Action Items 04/25/2016	04/25/16	Revise the Charter with edits from SC members (at the meeting and in writing) particularly regarding the Coordination Committee, Finance Committee, Revenue Committee, use of contingency funds, adding/changing members, financial management, and minimum balance for Reserve funds.	Meg Sedlak	07/20/16	Complete	
34	SC Action Items 04/25/2016	04/25/16	Report back to the SC in July as to whether additional funds, besides the extra $20,000 added to the FY15/16 budget, are needed for pathogens trigger studies.	Brian Lauerson	07/20/16	Complete	According to LWA, additional funds are not needed at this time.
35	SC Action Items 04/25/2016	04/25/16	Send meeting invitations for the next SC meetings on July 20, 2016 and October 18, 2016.	Thomas Jabusch	05/05/16	Complete	
36	SC Action Items 04/25/2016	04/25/16	Add an agenda item to July SC meeting regarding the Hyallela workshop being organized by Regional Board.	Meg Sedlak	07/20/16	Complete	
37	TAC Action Items from 3/30/15	03/30/16	Confirm that the Delta RMP website is up to date	Selina Cole	06/14/16	Complete	
38	TAC Action Items from 3/30/15	03/30/16	Send out to the TAC the consensus-based option for FY16/17 studies	Meg Sedlak	04/01/16	Complete	
39	TAC Action Items from 3/30/15	03/30/16	Revise scope of work for nutrient study for FY16/17 and send back to TAC	Thomas Jabusch	04/14/16	Complete	
40	TAC Action Items from 3/30/15	03/30/16	Trouble-shoot PDF printing problems at Regional San (Agenda package does not print correctly)	Meg	04/14/16	Complete	
41	SC Action Items from 12/18/15	12/18/15	Update table of upcoming management decisions and send back out to the SC →Delete Central Valley Diuron TMDL from table →Check status of State Water Board's proposed NNE policy for inland waters and updated as necessary →Change NNE-Delta to Delta Nutrient Research Plan	Meg Sedlak	04/25/16	Complete	
42	SC Action Items from 12/18/15	12/18/15	Respond to the SC's questions regarding how "risk potential" would be determined for prioritizing target current use pesticides for monitoring	TAC members	04/25/16	Complete	On March TAC agenda
43	SC Action Items from 12/18/15	12/18/15	Develop a Cost Allocation Schedule for SC approval that divides the $948,000 revenue target for FY16/17 between the Participant Groups	Meg Sedlak	04/25/16	Complete	Prepared and discussed with SC co-chairs
44	SC Action Items from 12/18/15	12/18/15	Recruit an appropriate representative to fill the new stormwater seat on the SC	Stephanie Hiestand	04/25/16	Complete	Brendan Ferry has agreed to serve
45	SC Action Items from 12/18/15	12/18/15	Finalize meeting summary from December 18, 2015	Thomas Jabusch	04/25/16	Complete	
46	SC Action Items from 12/18/15	12/18/15	Arrange a call between Greg Gearheart and ASC data management staff regarding State Board data management policies, CD3, and the Estuaries Portal	Meg Sedlak	04/25/16	Complete	
47	SC Action Items from 12/18/15	12/18/15	Follow up with TMDL staff about federal requirements so that compliance data issues for Vernalis compliance point can be resolved	Adam Laputz	04/25/16	Complete	RB staff coordinated with coalitions and labs re pesticide data.
48	SC Action Items from 12/18/15	12/18/15	Arrange a call between Adam Laputz, Greg Gearhart, and Tom Mumley to discuss coordination between the RMPs.	Meg Sedlak	04/25/16	Complete	
49	SC Action Items from 12/18/15	12/18/15	Discuss whether there is any value in testing bivalve samples collected by the Bay RMP for parameters of interest to the Delta RMP	TAC members	04/25/16	Complete	This task was deleted because it was not deemed relevant after a conference call between RB2 and RB5.
50	SC Action Items from 12/18/15	12/18/15	Schedule a call of the External Review Planning Subcommittee in January. Participants: Linda Dorn, Adam Laputz, Dave Tamayo, Val Connor, David Cory, Gregg Erickson, Sam Harader, Stephen McCord, and Joe Domagalski.	Philip Trowbridge	12/31/15	Complete	

	Primary	Meeting Date	Deliverable	Assigned To	Due Date	Status	Comments
51	SC Action Items from 12/18/15	12/18/15	Send doodle poll for an alternate date, set next meeting date, reserve room, and send invitations to the SC	Meg Sedlak	01/15/16	Complete	
52	SC Action Items 12/18/15	12/18/15	Patrick and Selina to prepare informational factsheet for Stormwater Phase II reps explaining the value of the program.	Patrick Morris	08/01/16	Complete	Fact sheet prepared by LWA.
53	TAC Action Items from 11/16/15	11/16/15	Draft strawman for the charge of the expert panel and distribute to the planning subcommittee	Philip Trowbridge	12/18/15	Complete	Charge drafted and distributed to planning committee.
54	TAC Action Items from 11/16/15	11/16/15	Convene planning subcommittee in the week after Thanksgiving	Philip Trowbridge	12/04/15	Complete	Meeting scheduled for 12/7/15.
55	TAC Action Items from 11/16/15	11/16/15	Present draft charge for the expert panel to the SC	Philip Trowbridge	12/18/15	Complete	Charge drafted and on SC agenda.
56	TAC Action Items from 11/16/15	11/16/15	Bring outline for the Nutrient Synthesis Workgroup to the SC and clarify that the proposed target date will be adjusted as needed to allow sufficient time for the development process	Philip Trowbridge	12/18/15	Complete	Workplan updated and on SC agenda.
57	TAC Action Items from 11/16/15	11/16/15	Plan a future discussion with the TAC to outline the process for updating the target analyte list and defining how risk should be considered	Thomas Jabusch	04/01/16	Complete	On March TAC meeting
58	TAC Action Items from 11/16/15	11/16/15	Distribute W. Fleenor's paper to the TAC	Stephen McCord	11/20/15	Complete	
59	SC Action Items from 10/23/15	10/23/15	Update SC roster	Thomas Jabusch	10/30/15	Complete	
60	SC Action Items from 10/23/15	10/23/15	Put an item on the next agenda to discuss the requests for additional Steering Committee seats for Phase I and Phase II stormwater and the State Board and the overall balance and composition of the committee	Philip Trowbridge	11/18/15	Complete	Recorded in list of potential agenda items
61	SC Action Items from 10/23/15	10/23/15	Provide a list of appropriate candidates from fisheries agencies for the vacant Resource Agencies seat	Tim Vendlinski	12/18/15	Complete	
62	SC Action Items from 10/23/15	10/23/15	Update minutes with edits requested by Val and post to Regional Board website	Thomas Jabusch	10/30/15	Complete	Updated summary sent to Regional Board staff to post
63	SC Action Items from 10/23/15	10/23/15	Update TAC summary with the correct station name for the Mokelumne on page 4 (New Hope Road)	Thomas Jabusch	10/30/15	Complete	
64	SC Action Items from 10/23/15	10/23/15	Get provisional pesticide data from USGS and post with the rest of the provisional data on the TAC website	Thomas Jabusch	10/30/15	Complete	
65	SC Action Items from 10/23/15	10/23/15	Get information on the DSP peer review process from Val Connor and share it with the Steering Committee.	Philip Trowbridge	10/30/15	Complete	
66	SC Action Items from 10/23/15	10/23/15	Talk to the Delta Science Program about getting an external review of the Monitoring Design. Coordinate with Val and Gregg on this item	Philip Trowbridge	12/18/15	Complete	
67	SC Action Items from 10/23/15	10/23/15	Convene the Finance and Revenue Subcommittees for kick-off meetings	Val Connor	12/18/15	Complete	
68	SC Action Items from 10/23/15	10/23/15	Put an item on the agenda for the fall 2016 SC meeting to review the Program expenses compared to other similar programs, the goals of the Program, and the multi-year trajectory of the Program	Philip Trowbridge	10/31/16	Complete	Provided a cost comparison at the April SC meeting.
69	SC Action Items from 10/23/15	10/23/15	Follow up with Val and Mike about the Finance Subcommittee to find out what assistance they need from ASC	Philip Trowbridge	10/30/15	Complete	
70	SC Action Items from 10/23/15	10/23/15	Develop a proposal for an interlaboratory comparison study for pesticides for the TAC to review	Josie Tellers	11/09/15	Complete	
71	SC Action Items from 10/23/15	10/23/15	Review and provide comments on the draft Communications Plan	Steering Committee	11/06/15	Complete	No additional comments were provided.

	Primary	Meeting Date	Deliverable	Assigned To	Due Date	Status	Comments
72	SC Action Items from 10/23/15	10/23/15	Develop ideas for a fact sheet to support fundraising efforts	Val Connor	12/18/15	Complete	Past fact sheets were compiled by ASC and will be presented to the SC.
73	SC Action Items from 10/23/15	10/23/15	Review and provide comments on the draft Program Planning Overview	Steering Committee	11/06/15	Complete	No additional comments were provided.
74	SC Action Items from 10/23/15	10/23/15	Add the July 7, 2014, version of the RMP-RB Interaction Flow Chart to the RMP Foundations document with an introduction that explains that this flow chart was a foundational document and the basis for language that was added to permits. The introduction should also explain that the purpose of the flow chart is to show mutual expectations that the RMP will be used to collaboratively study issues as much as possible to avoid additional study requests from the Water Board on top of the RMP	Thomas Jabusch	12/18/15	Complete	
75	SC Action Items from 10/23/15	10/23/15	Revise adequate participation language and work with co-chairs on edits	Philip Trowbridge	12/18/15	Complete	
76	SC Action Items from 10/23/15	10/23/15	Set next meeting date for December 18, reserve room, and send invitations to the SC	Thomas Jabusch	10/30/15	Complete	

Delta RMP Deliverables Scorecard Report

Key to Status Colors:
Green indicates greater than 90 days until the deliverable is due.
Yellow indicates a deliverable due within 90 days.
Red indicates a deliverable that is overdue.

Project	Primary	Deliverable	Assigned To	Due Date	Status	Comments
Delta RMP (FY14/15)	Pathogens Monitoring	Set up contracts with BioVir and Eurofins	Thomas Jabusch	04/06/15	Complete	
Delta RMP (FY14/15)	Data Management	Prepare QAPP for FY14/15	Thomas Jabusch	04/15/15	Complete	QAPP completed and sent to SWAMP QAO for review.
Delta RMP (FY14/15)	Pesticide/Toxicity Monitoring	Set up contract with USGS for pesticide analyses	Thomas Jabusch	04/30/15	Complete	
Delta RMP (FY14/15)	Pesticide/Toxicity Monitoring	Arrange for UCD/ATL to participate in SCCWRP Interlaboratory Calibration Study	Thomas Jabusch	04/30/15	Complete	APHL will participate in the study without funding from the Delta RMP.
Delta RMP (FY14/15)	Nutrient Synthesis	Set up contract with USGS for synthesis of high-frequency sensor data	Thomas Jabusch	05/15/15	Complete	
Delta RMP (FY14/15)	Program Management	Revised Monitoring Design	Thomas Jabusch	05/22/15	Complete	The Monitoring Design has been revised and was sent to the TAC and SC on 6/8/15 for review.
Delta RMP (FY14/15)	Program Management	FY15-16 Annual Program Workplan	Philip Trowbridge	05/22/15	Complete	FY15/16 Budget and Workplan sent to SC on 6/9/15.
Delta RMP (FY14/15)	Program Management	Framework for Interpretation of Monitoring Results	Thomas Jabusch	05/22/15	Complete	An outline for the Communications Plan was included in the revised Monitoring Design sent on 6/8/15 and will be discussed at the 6/16/15 SC meeting.
Delta RMP (FY14/15)	Program Management	FY15/16 Revenue Projections and Plan for Efficiently Invoicing Participants	Philip Trowbridge	05/22/15	Complete	
Delta RMP (FY14/15)	Program Management	Quarterly financial reports	Lawrence Leung	05/31/15	Complete	
Delta RMP (FY14/15)	Program Management	System for tracking deliverables and action items	Philip Trowbridge	05/31/15	Complete	For June SC meeting
Delta RMP (FY14/15)	Data Management	Set up templates and EDD reports for the pesticide/toxicity and pathogen laboratories	Amy Franz	05/31/15	Complete	EDDs for pathogens labs have been created. EDDs for pesticide/toxicity labs has been deferred to FY15/16.
Delta RMP (FY14/15)	Pesticide/Toxicity Monitoring	Collect two rounds of samples and analyze the samples for pesticides and toxicity	Contractors	06/30/15	Complete	This task has been deferred to FY15/16 workplan.
Delta RMP (FY14/15)	Nutrient Synthesis	Final report on high-frequency sensor data nutrient synthesis	Brian Bergamashi	12/31/15		USGS draft report has been presented to TAC for review. Report is being revised based on internal USGS comments. Revised report will be sent to TRC and SC in October 2016.
Delta RMP (FY14/15)	Pathogens Monitoring	Pathogens Year 1 Final report	Contractors	06/30/16	Complete	Summary memo provided to TAC.
Delta RMP (FY15/16)	Program Management	Supplemental Budget Request to analyze split samples for CUPs	Thomas Jabusch	08/31/15	Complete	

Project	Primary	Deliverable	Assigned To	Due Date	Status	Comments
Delta RMP (FY15/16)	Program Management	Prop 1 Application	Jennifer Sun	09/16/15	Complete	An application for 2 years of mercury monitoring ($640k) was submitted in response to the DFW solicitation.
Delta RMP (FY15/16)	Governance	TAC Meeting #1 and Summary	Thomas Jabusch	09/30/15	Complete	
Delta RMP (FY15/16)	Communications	Communications Plan	Thomas Jabusch	09/30/15	Complete	The draft Communications Plan and Program Planning Outline were sent to the TAC on 9/17/15 and the Steering Committee on 10/15/15.
Delta RMP (FY15/16)	Governance	Steering Committee Meeting #1 and Summary	Philip Trowbridge	10/30/15	Complete	
Delta RMP (FY15/16)	Governance	TAC Meeting #2 and Summary	Thomas Jabusch	12/31/15	Complete	
Delta RMP (FY15/16)	Governance	Steering Committee Meeting #2 and Summary	Philip Trowbridge	01/31/16	Complete	
Delta RMP (FY15/16)	Communications	Communications Product (The Charter)	Meg Sedlak	01/31/16	Complete	Charter was approved at 7/20/16 meeting.
Delta RMP (FY15/16)	Program Management	MOU for financial management and invoicing	Philip Trowbridge	03/31/16	Complete	MOU was discussed at the 4/25/16 SC meeting. The SC recommended changing the document to be a contract template for entities that need a contract to pay their fees. The MOU was sent to those entities to consider for a template.
Delta RMP (FY15/16)	Governance	TAC Meeting #3 and Summary	Thomas Jabusch	03/31/16	Complete	
Delta RMP (FY15/16)	Governance	Steering Committee Meeting #3 and Summary	Philip Trowbridge	04/29/16	Complete	
Delta RMP (FY15/16)	Nutrients Synthesis	Nutrient Synthesis - Preparation of a memorandum summarizing recommendations for FY16/17	Thomas Jabusch	04/30/16	Complete	A draft of the report will be prepared by April 30, 2016 so that the recommendations can be considered for funding in the FY16/17 Workplan. The final report will be completed by June 30, 2016.
Delta RMP (FY15/16)	Program Management	FY16/17 Annual Workplan and Budget	Philip Trowbridge	05/13/16	Complete	Draft in May 2016. Final by June 30, 2016.
Delta RMP (FY15/16)	Governance	Steering Committee Meeting #4 and Summary	Philip Trowbridge	06/30/16	Complete	
Delta RMP (FY15/16)	Governance	TAC Meeting #4 and Summary	Thomas Jabusch	06/30/16	Complete	
Delta RMP (FY15/16)	Quality Assurance	QAPP Update	Thomas Jabusch	06/30/16	Complete	The QAPP was revised to reflect the addition of mercury monitoring. QAPP was approved by SC in July 2016. State and SWAMP QAOs have re-confirmed their approval. All that remains to be done is to collect all signature, which is delayed due to summer vacation schedules.
Delta RMP (FY15/16)	Pathogens Study	Data Management of Year 1 Pathogens Data	Amy Franz	07/31/16	Complete	Data from BioVir and Eurofins has been uploaded to SFEI's RDC database; it takes approximately 2 weeks for it to be loaded into CEDEN.
Delta RMP (FY15/16)	Pathogens Study	Quality Assurance Report on Year 1 Pathogens Data	Don Yee	09/30/16	Complete	QAO report. The report is on the agenda for the 9/20/16 TAC meeting.
Delta RMP (FY15/16)	CUP Monitoring	Field Sampling Report for FY15/16 CUP Monitoring	Ila Shimabuku	09/30/16	Complete	On agenda for 9/20/16 TAC meeting
Delta RMP (FY15/16)	Nutrients Synthesis	Nutrient Synthesis - Convene 2-day workshop with expert panel in October 2016.	Thomas Jabusch	10/31/16	Complete	Workshop convened on 9/30/16.
Delta RMP (FY15/16)	CUP Monitoring	Data Management of FY15/16 CUP Data	Amy Franz	12/31/16		Pesticide, toxicity, copper, carbon, SSC. Labs: USGS and UCD and a second pesticide lab to be named later. Data need to be uploaded to CEDEN by 2/1/17.
Delta RMP (FY15/16)	CUP Monitoring	Quality Assurance Report for FY15/16 CUP Monitoring	Don Yee	12/31/16		

Project	Primary	Deliverable	Assigned To	Due Date	Status	Comments
Delta RMP (FY15/16)	Nutrients Synthesis	Nutrient Synthesis - Based on workshop, prepare draft report summarizing recommendations for on-going monitoring plan development. Draft 12/31/2016. Final 3/31/2017	Thomas Jabusch	12/31/16	Complete	
Delta RMP (FY15/16)	CUP Monitoring	Annual Monitoring Report for FY15/16 CUP Monitoring	Thomas Jabusch	02/28/17		Data need to be uploaded to CEDEN by 2/1/17.
Delta RMP (FY15/16)	Pathogens Study	Data Management of Year 2 Pathogens Data	Amy Franz	07/31/17		Data from BioVir and Eurofins. Formatting, transcribing field collection information, performing QA/QC review, and uploading field and analytical results to SFEI's RDC database and replicating to CEDEN.
Delta RMP (FY15/16)	Pathogens Study	Quality Assurance Report on Year 2 Pathogens Data	Don Yee	07/31/17		QAO report. Funded from Data Management budget.
Delta RMP (FY16/17)	Governance	Steering Committee Meeting #1 and Summary	Meg Sedlak	07/20/16	Complete	SC draft minutes sent to group for comments.
Delta RMP (FY16/17)	Program Management	Completion of the MOA	Philip Trowbridge	09/01/16	Complete	MOA was completed and used as a bilateral agreement between ASC and Regional San.
Delta RMP (FY16/17)	Program Management	Proposal for Prop 1 Funding	Meg Sedlak	09/21/16	Complete	Prop 1 Hg proposal submitted.
Delta RMP (FY16/17)	Governance	TAC Meeting #1 and Summary	Philip Trowbridge	09/21/16	Complete	
Delta RMP (FY16/17)	Governance	Financial Subcommittee report and conference call	Philip Trowbridge	09/29/16	Complete	Report delivered on 9/26. Conference call held on 9/29.
Delta RMP (FY16/17)	Communications	Preparation of a Factsheet	Thomas Jabusch	09/30/16		This topic was on the agenda for the SC in July but was not discussed. The task will be delayed pending direction from the SC.
Delta RMP (FY16/17)	Governance	Steering Committee Meeting #2 and Summary	Philip Trowbridge	10/18/16		Agenda package out by 10/11. Need to revise agenda. Prepare MYP materials. Prepare SWAMP funds memo. Edit financial report. Prepare consent calendar items: USGS report, CUP report, QAO report.
Delta RMP (FY16/17)	Nutrients Synthesis	7C3.1 Nutrients- Statistical Modeling	Thomas Jabusch	10/24/16		•11/01/16: Nutrient subcommittee meeting/call (same meeting/call as in Task 2) •11/01/16: Comments due •1/31/16: All additional statistical modeling complete •2/28/16: Draft outline to Nutrient Subcommittee/TAC •3/31/16: Comments due •5/31/17: Draft report to Nutrient Subcommittee/TAC •6/15/17: Comments due •6/30/17: Final technical report to SC
Delta RMP (FY16/17)	Nutrients Synthesis	7A1.2 Synthesis Report - compile additional data and information	Thomas Jabusch	10/31/16		•10/31/16: Compile all of the following: 1.IEP-EMP data report (ASC) - done 2.DSP report (ASC) - done 3.Delta RMP Sensor Synthesis (USGS) 4.WRTDS/GAMA results (USEPA/ASC)
Delta RMP (FY16/17)	Nutrients Synthesis	7B2.1 Modeling and Synthesis of Modeling Results - Convene nutrient subcommittee in-person meeting or conference call	Thomas Jabusch	11/01/16		Call scheduled for 11/08/16 •11/01/16: Develop work materials for call •11/08/16: Convene conference call
Delta RMP (FY16/17)	Nutrients Synthesis	7B2.2 Modeling and Synthesis of Modeling Results - Select appropriate model and design experiments	Thomas Jabusch	11/08/16		•11/8/16: Draft model design to Nutrient Subcommittee •11/16/16: Comments due •11/30/16: Model design complete
Delta RMP (FY16/17)	Governance	TAC Meeting #2 and Summary	Thomas Jabusch	12/19/16		

Project	Primary	Deliverable	Assigned To	Due Date	Status	Comments
Delta RMP (FY16/17)	Program Management	Updated Multi-Year Plan	Philip Trowbridge	12/30/16		
Delta RMP (FY16/17)	CUP Monitoring	6. Quality Assurance Report for FY16/17 CUP Monitoring	Don Yee	12/31/16		
Delta RMP (FY16/17)	Nutrients Synthesis	7B2.3 Modeling and Synthesis of Modeling Results - Run simulations	Thomas Jabusch	12/31/16		•12/31/16: All simulations complete
Delta RMP (FY16/17)	Nutrients Synthesis	7B2.4 Nutrients - Analyze and synthesize model output data	Thomas Jabusch	12/31/16		•1/31/16: All output data analyses complete •2/28/16: Draft outline to Nutrient Subcommittee/TAC •3/31/16: Comments due •5/31/17: Draft report to Nutrient Subcommittee/TAC •6/15/17: Comments due •6/30/17: Final technical report to SC
Delta RMP (FY16/17)	Governance	Financial Subcommittee report and conference call	Philip Trowbridge	01/05/17		Next report should add a column to separate deliverables/outcomes from outputs in the work completed summary.
Delta RMP (FY16/17)	Governance	Steering Committee Meeting #3 and Summary	Philip Trowbridge	01/26/17		
Delta RMP (FY16/17)	Nutrients Synthesis	7A1.1 Synthesis Report - Additional data analyses	Thomas Jabusch	01/31/17		•9/30/16: Download most recent IEP-EMP data **as of 10/04/16, the most recent data posted are from FY15. These data have already been downloaded. Contacted EMP to inquire about availability of FY16 data.** •1/31/16: All analyses complete
Delta RMP (FY16/17)	Program Management	FY17/18 Annual Workplan and Budget	Philip Trowbridge	02/10/17		Early draft for Finance Subcommittee by 2/10/17. Draft for SC by 4/30/17. Final by 6/30/16.
Delta RMP (FY16/17)	Program Management	Updated Monitoring Design	Philip Trowbridge	02/15/17		
Delta RMP (FY16/17)	Nutrients Synthesis	7A1.3 Synthesis Report - Prepare synthesis report	Thomas Jabusch	02/28/17		•2/28/16: Draft outline with example write-ups/graphs/maps to Nutrient Subcommittee/TAC •3/31/16: Comments due •5/31/17: Draft report to Nutrient Subcommittee/TAC •6/15/17: Comments due •6/30/17: Final technical report to SC
Delta RMP (FY16/17)	Governance	TAC Meeting #3 and Summary	Thomas Jabusch	03/15/17		
Delta RMP (FY16/17)	Governance	Steering Committee Meeting #4 and Summary	Philip Trowbridge	04/12/17		
Delta RMP (FY16/17)	Governance	TAC Meeting #4 and Summary	Thomas Jabusch	06/14/17		
Delta RMP (FY16/17)	Quality Assurance	QAPP Update	Thomas Jabusch	06/14/17		
Delta RMP (FY16/17)	Communications	Technical Workshop / summary memorandum of findings	Philip Trowbridge	06/30/17		Purpose of workshop TBD
Delta RMP (FY16/17)	CUP Monitoring	6. Field Sampling Report for FY16/17 CUP Monitoring	Philip Trowbridge	09/29/17		Review and then task Thomas with other edits.
Delta RMP (FY16/17)	CUP Monitoring	6. Data Management of FY16/17 CUP Data	Amy Franz	12/31/17		
Delta RMP (FY16/17)	CUP Monitoring	6. Permit Compliance Data for ILRP	Amy Franz	02/01/18		
Delta RMP (FY16/17)	CUP Monitoring	6. Annual Monitoring Report for FY16/17 CUP Monitoring	Thomas Jabusch	02/28/18		
Delta RMP (FY16/17)	Mercury	8. Mercury YR1 report summarizing fish and water analyses	Thomas Jabusch	12/03/18		

Delta RMP Prop 1 Proposal Summary

Project Title: Monitoring for Mercury in Delta Fish, Water and Sediment by the Delta Regional Monitoring Program

Applicant name: Aquatic Science Center (the Implementing Agency for the Delta Regional Monitoring Program)

Total Funding Requested: $507,028

Total Matching Funds Pledged: $144,000

Proposal Submitted On: June 23, 2016

Expected Date for Funding Decision by CDFW: November 2016

Executive Summary/Abstract

The purpose of this project is to comprehensively evaluate mercury cycling in Delta sediment and water, and the uptake of methylmercury (MeHg) into fish. Over a three-year time frame, this project will conduct annual monitoring of higher trophic level fish and correlate this information to quarterly mercury and MeHg water and sediment concentrations measured at co-located sites. This project design was developed by the Delta Regional Monitoring Program (Delta RMP); in particular, it was developed by the Mercury subcommittee and vetted by the Technical Advisory Committee and the Steering Committee, each of which is composed of scientists, state and federal regulators, and engaged stakeholders.

This study is of critical importance to the Delta Science Program's co-equal goals of providing reliable and clean water supplies to California and restoring and enhancing Delta habitats. This proposal addresses two of the high-impact science actions endorsed by the Delta Plan Interagency Implementation Committee: 1) Implementation of the Delta RMP; and 2) Completion of Regulatory Processes, Research and Monitoring for Water Quality Improvement including the Delta MeHg Total Maximum Daily Load (TMDL). The Delta Plan specifically recommends that "Further study is needed to determine the dominant processes affecting MeHg concentrations in food webs in the Delta" (p.228).

Historical use of mercury in gold mining has resulted in elevated concentrations of mercury in water, sediment, and biota in the Delta and the San Francisco Bay. Much of the mercury data available for the Delta was collected over a decade ago and the data does not reflect current conditions, particularly after four years of drought. As California moves to restore 30,000 acres to wetlands under the California EcoRestore program in the next four years, it will be of critical importance to have recent data on the concentration of mercury in water, sediment, and fish to identify areas that may have high potential for MeHg production and uptake and to mitigate these impacts.

Secondly, information from this project will be used directly by the Department of Water Resources to calibrate and validate a hydrodynamic model that the Department is developing. The model is part of a requirement of the Delta Mercury Control Program to evaluate operational strategies to reduce mercury and MeHg concentrations in the Delta and Yolo bypass. This data will be critical to the development of the Delta mercury model (see Letter of Support from Ms. Carol DiGiorgio Program Manager, Division of Environmental Services, Mercury Monitoring and Evaluation Section, the Department of Water Resources). This model will be important for assessing the effects of changes in flow, habitat, water quality, and food web dynamics in the Delta.

Thirdly, this proposal will support the implementation of the Delta MeHg TMDL by providing recent data on mercury concentrations in fish, water, and sediment. The goal of the Delta MeHg TMDL is to reduce mercury levels in fish in the Delta through the control of mercury and MeHg. The data from this project will provide information to assess the production and uptake of MeHg and assist regulators in optimizing methods to reduce the formation of MeHg (see Letter of Support from Janis Cooke, Central Valley Regional Water Quality Control Board).

Introduction and Purpose

The purpose of this project is to take a comprehensive look at MeHg cycling in Delta by monitoring mercury in water, sediment, and fish over a three-year period. The Delta RMP has completed a comprehensive five-year Monitoring Design (10-year Monitoring Design for fish) (http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_regional_monitoring/wq_monitoring_plans/drmp_monitoring_design.pdf), including monitoring for MeHg, nutrients, current use pesticides, and pathogens in water, sediment, and fish tissue in the Delta. This proposal is for funding to implement the recommended design for MeHg monitoring in water, sediment, and fish tissue for three years. Specifically, water and sediment samples will be collected quarterly at 6 stations and analyzed for MeHg, total mercury and supplemental parameters. Fish will be collected from the same 6 sites once each year. The indicator of primary interest will be MeHg (total mercury used as a proxy for MeHg for cost savings; Bloom 1992) in muscle fillets of largemouth bass (or similar predator species) over the three-year period.

Impairment of the Delta due to MeHg is a high priority issue for water quality managers in the Delta as well as downstream in the San Francisco Bay. In 2010, the Central Valley Regional Water Quality Control Board approved a Delta MeHg TMDL that established numeric targets for water and fish tissue. This proposal represents the first coordinated effort to support long-term monitoring in support of implementing the MeHg TMDL. Sediment data produced through this project will also fill key data gaps in the Department of Water Resources (DWR) computer model for mercury in the Delta.

Spatial patterns in sport fish MeHg in the Delta have been fairly well-characterized, but very few data are available on interannual variation and long-term trends. Sampling at seven locations in the Delta by the Surface Water Ambient Monitoring Program in 2011 (Davis et al. 2013) confirmed the spatial pattern observed in previous surveys going back to 1998 (Davis et al. 2000, Davis et al. 2008, Melwani et al. 2009), with high concentrations around the edges of the Delta and low concentrations in the Central Delta. Time series based on repeated, directly comparable measurements at specific Delta locations are lacking, but are needed for an accurate characterization of long-term trends. Rigorous trend monitoring of Delta sport fish will be an essential performance measure for evaluation of the effectiveness of the MeHg TMDL (Wood et al. 2010), which has established numeric criteria for mercury in fish tissues that are calculated based on consumption rates in the diet and fish trophic level**.** Currently, the best data available are flawed due to inconsistencies in sampling location, sample sizes, size ranges, and species, but do suggest consistent concentrations over time, with relatively high concentrations at the sites around the northern periphery of the Delta (ranging between approximately 0.60 and 0.80 ppm wet weight), and lower concentrations at the locations in the Central Delta (ranging between approximately 0.20 and 0.30 ppm).

The MeHg TMDL also established a water concentration implementation goal of 0.06 ng/L unfiltered MeHg. Past studies have evaluated at spatial and temporal patterns of Delta water mercury and MeHg concentrations (Foe, 2003; Foe et al., 2008; Heim et al., 2008; Louie et al., 2008). However, time series measurements of mercury and MeHg water concentrations based on repeated, directly comparable measurements have not been made since 2006 in the Delta. These measurements are needed for an

accurate characterization of long-term trends. Monitoring of water concentrations to track performance relative to the TMDL goal will provide a valuable tool for managing MeHg discharges to the Delta and for understanding processes leading to accumulation in fish and impairment.

Previous work also identified large scale spatial trends of mercury and MeHg sediment concentrations in the Delta (Heim et. al, 2007). This study indicated lower MeHg sediment concentrations around the edges of the Delta and high concentrations in the Central Delta. A comparison of these results with previous observations of sediment and biota concentrations suggests that a disconnect exists between *in situ* production of MeHg in sediment and uptake by biota in the Delta. However, this analysis used fish and sediment data from sites that were not co-located. Time series of mercury and MeHg sediment concentrations have been generated at a limited number of sites within the Delta, but the most recent was collected 2005. MeHg sediment concentrations were generally higher in the spring and summer relative to other times of year (Heim et al., 2007; Heim et al., 2008). This project will collect sediment for mercury analysis at sites collocated with fish and water collections to further improve our understanding of how *in situ* MeHg production affects bioaccumulation in Delta fish.

Mercury data generated by this project will also provide critical input data for a mercury model being developed by DWR and other stakeholder agencies to evaluate operational impacts on open water MeHg production and conduct scenario testing to examine how changes in the operational environment could impact open water MeHg inputs in the Delta. DWR's DSM2 model is being updated and expanded to include mercury and sediment modules (both bed and suspended). DSM2 is already a widely used model of Delta flows and water quality. In the Yolo Bypass, the Dynamic Mercury Cycling Model (D-MCM) is being used: D-MCM models mercury cycling, while hydrodynamics are provided from TUFLOW. Mercury and ancillary measurements collected as part of the Delta RMP will be very valuable in support of ongoing efforts to model mercury cycling in the Delta. An important step in the modeling study is to calibrate the model to fit observations of existing mercury levels in the Delta. While there are existing measurements of total and MeHg concentrations in Delta sediments as referenced above, the information is becoming somewhat dated to use as a measure of current conditions. Updated measurements of total mercury and MeHg concentrations in surface sediments in the Delta would be ideal for model calibration purposes. Additional information on sediment characteristics known to affect mercury concentrations will also be critical for understanding mercury cycling, including total organic carbon, acid volatile sulfide, and grainsize information. If successful, this model will provide managers with a tool to evaluate MeHg trends associated with changes to operational conditions, and has the potential to be expanded and used by other stakeholders to evaluate MeHg trends associated with other activities in the Delta and Yolo Bypass. Understanding the role that sediment plays in the production and uptake of MeHg into the food web will also be important for informing monitoring of habitat restoration projects.

This project will be conducted as part of a wider monitoring effort undertaken by the Delta RMP. The Delta RMP's mission is to inform decisions on how to protect, and where necessary, restore beneficial uses of water in the Delta, by producing objective and cost-effective scientific information critical to understanding regional water quality conditions and trends.

The Delta RMP has worked collaboratively to articulate high priority management questions for contaminants that pose a threat to the health of the Delta (i.e., nutrients, pesticides, pathogens and mercury). The Delta RMP mercury management questions are:

- What are the status and trends in ambient concentrations of total mercury and MeHg in fish, water, and sediment, particularly in subareas likely to be affected by major sources or new sources (e.g., large scale restoration projects)?
    - Are trends over time in MeHg in sport fish similar or different among Delta subareas?
    - Are trends over time in MeHg in water similar or different among Delta subareas?

This work also directly addresses the priorities of the Department of Fish and Wildlife Service Prop 1 Solicitation including:

- "Contribute to the Improvement of Water Quality. The objective of this priority is to implement multi-benefit projects that contribute to the improvement of water quality in the Delta to improve ecosystem condition, functions, and resiliency…" This project will specifically address this priority by supporting the implementation of the Delta MeHg TMDL (Wood et al., 2010) and providing data to fill several key information gaps such as temporal trends in the Delta sport fish and recent water and sediment mercury data.
- "Scientific Studies to Support Implementation of the Delta Science Plan. This Solicitation is seeking proposals that are partnered with collaborative science initiatives (e.g. Delta RMP) and are consistent with the high-impact science actions endorsed by the Delta Plan Interagency Implementation Committee, and address one or more of the following topics"
    a. "Topic 1. Assessing the effects of extreme events on the Delta"
    This project will evaluate MeHg concentrations over a three-year time frame and may provide insight into MeHg production during drought and/or flood conditions. This project will monitor, to the extent possible, the impact of drought-induced environmental (e.g., physical, chemical, and biological) changes on MeHg production and uptake into fish. In addition, because mercury monitoring is only one of four major elements of the Delta RMP, additional information on water quality will be available to provide context.
    b. "Topic 2. Development and coupling modeling and other tools to support resource management in the Delta"
    This project will provide critical data for the development of a mercury cycling model currently being developed by the DWR and other stakeholder agencies. This model will provide managers with a tool to evaluate MeHg trends associated with changes to operational conditions and potentially other activities such as restoration efforts.

The list of Delta Plan Interagency Implementation Committee-endorsed actions includes monitoring programs that have been prioritized for implementation by Delta RMP:

> "Fund research identified by various efforts such as…[the] Delta Regional Monitoring Program (Delta RMP)" (DPIIC 2015).

Since the mercury monitoring project is a high priority monitoring program for the Delta RMP, it is a good match to the DFW solicitation.

Additionally, this project addresses several specific actions in the California Water Action Plan, including:

3. "Achieve the co-equal goals for the Delta". One of the specific objectives of this plan is to "Restore Delta Aquatic and Intertidal Habitat". Mercury that is sequestered in soils and sediments may be released during restoration projects. Monitoring of contaminant concentrations in water and wildlife will assist in our understand of the water quality impacts of habitat restoration projects and provide the information necessary to identify regions of the Delta where there may be contaminant threats to Delta wildlife. It will also serve as baseline dataset before restoration projects are completed.

4. "Protect and restore important ecosystems". One of the specific objectives of this plan is to "Bring Back Salmon to the San Joaquin River." Mercury bioaccumulates through fish trophic classes and may pose a risk to migrating and spawning salmon. Data from this project will help identify where, when and how mercury contamination presents the greatest ecosystem threat, and will support more targeted protection and restoration of these areas.

Furthermore, this project will provide multiple additional benefits:

- It will improve our understanding of mercury cycling in the Delta and ways that water quality managers can mitigate the production of MeHg. This information will be useful for assessing water quality under the California Wildlife Action Plan.
- It will provide information on MeHg concentrations in fish that subsistence fishers consume, which will be useful for updating existing fish consumption advisories.
- It will assist in our ability to manage estuaries to reduce stress on native fish populations. MeHg concentrations in fish in some portions of the Delta are high enough to pose risks to the health of fish themselves. This information will also be relevant to the State Recovery Plan for Endangered Species.

The Aquatic Science Center (ASC), acting as the Implementing entity for Delta RMP, will administer the funds for the project, and will retain Moss Landing Marine Laboratory to conduct sample collection and chemical analyses, and to collaborate with ASC on a final report. ASC will conduct data review and upload of the data to the California Environmental Data Exchange Network (CEDEN). The work tasks for ASC and Moss Landing Marine Laboratory are outlined in the following sections.

Project History / Need for CDFW Funds

Mercury contamination is one of the most significant water quality issues facing the health of wildlife and humans in the Bay-Delta. Both the Central Valley and the San Francisco Bay Regional Water Quality Control Boards have classified the Delta and Bay as impaired due to elevated mercury levels and have developed TMDL control plans to reduce the impairment. Other actions are also underway or being contemplated in the Delta that could affect mercury accumulation in the food web, including large-scale habitat restoration and hydrological alterations. Understanding the spatial distribution and temporal trends of mercury in the Delta is urgently needed to track the impacts of these management actions on mercury contamination.

The Delta RMP is extremely well-positioned to characterize mercury in Delta fish, water, and sediment. The Delta RMP was initiated by the Central Valley Regional Water Quality Control Board with the primary goal of tracking and documenting the effectiveness of beneficial use protection and restoration efforts through comprehensive monitoring of water quality constituents and their effects in the Delta. The Delta RMP reflects an increasing desire among water quality and resource managers throughout the state for more integrated and complete information about patterns and trends in ambient conditions across watersheds and regions. Many stressors on beneficial uses are interrelated and need to be addressed more holistically to fully understand the problem. The Delta RMP is a stakeholder-driven multi-faceted monitoring program that coordinates among local, regional, and state entities, and is the appropriate entity to undertake the mercury monitoring that is needed in the Delta.

The Delta RMP has developed a comprehensive program to monitor for basic water quality parameters, nutrients, pesticides, toxicity, pathogens, and mercury. It is now in its second year of implementation; however, as a nascent program, it does not have the financial resources to implement the monitoring design at full scale. As a result, the Delta RMP was unable to monitor for mercury in its first year (2015). By phasing out some elements, the RMP has been able to begin implementation of mercury monitoring in FY16/17 (July 1, 2016); however, it is not clear that the Program will be able to continue monitoring mercury every year for the next few years as the Program seeks to balance many information needs with the existing budgets. The Program is actively seeking new ways to obtain additional funding and is optimistic that it will secure additional revenue; however, this may take time. In the meantime, it is extremely important to begin tracking interannual variation and long-term trends in mercury now to

provide information to State agencies relevant to the efficacy of the MeHg TMDL and the development of a calibrated mercury hydrodynamic model. There is a critical need for mercury data now to assess the TMDL and to develop a mercury model as the State begins to restore habitats; it is these needs that are driving the Delta RMP to seek external funds from Prop 1.

The Delta RMP is collaborative monitoring program that includes regulators from a variety of regional, state, and national agencies (e.g., National Oceanic Atmospheric Administration National Marine Fisheries Service, Regional Water Quality Control Board, State Water Resources Control Board, Interagency Ecological Program, US Geological Survey, Bureau of Reclamation, Department of Water Resources, and US Environmental Protection Agency,) and stakeholder groups (i.e., agriculture, wastewater treatment facilities, stormwater agencies, and water suppliers), all with the shared mission of providing coordinated water quality monitoring to track and document the effectiveness of beneficial use protection and restoration efforts. As such, the Program brings not only financial resources from a diverse set of stakeholders and in-kind contributions from a wide array of government entities, but also a considerable depth and breadth of knowledge and resources to address the complex issues that are facing the Delta. We anticipate that as the program matures over the next several years the financial contributions from new and existing stakeholders are likely to increase the current Delta RMP budget such that in 3 to 5 years, the mercury element of the Delta RMP monitoring design will be fully funded.

Goals and Objectives

Project Goal

- Inform management and regulatory decisions on how to protect, and where necessary, restore beneficial uses of water in the Delta by providing objective and cost-effective long term mercury data to improve understanding of regional water quality conditions and trends. These decisions include, but are limited to, Delta MeHg TMDL implementation, development of a mercury module for the DWR DSM2 model, wetland restoration plans, Fish Consumption Advisories, California Wildlife Action Plan goals, and the State Recovery Plan for Endangered Species.

Project Objectives

- Collect 3 years of MeHg concentration data in fish tissue samples from different subareas of the Delta (11 individual fish sampled at 6 fixed stations annually). The indicator of primary interest is MeHg in muscle fillet of 350-mm largemouth bass (or similar predator species). MeHg in muscle fillets of other high trophic level species are indicators of secondary interest.

- Collect 2.5 years of total MeHg concentration data in water samples from different subareas of the Delta (6 fixed stations measured quarterly). The indicator of primary interest is total MeHg in water. The last year of fish monitoring will correspond with the last half year of water sampling.

- Collect 2.5 years of total MeHg concentration data in sediment samples from different subareas of the Delta (6 fixed stations measured quarterly). The indicators of primary interest are total mercury and MeHg in sediment. The last year of fish monitoring will correspond with the last half year of sediment sampling.

- Prepare a synthesis report of data collected and deliver to the Delta RMP Steering Committee. This synthesis will answer the following management question: Are trends over time in MeHg in sport fish, sediment, and water similar or different among Delta subareas? Additional analyses will include comparisons of mercury results across matrices, time, and ancillary parameters in order to better understand factors influencing mercury transport and cycling. Provide data as input

to the DWR mercury model.

- Communicate findings to the Delta RMP stakeholders and regulatory partners through the Pulse of the Delta publications, meetings, and final synthesis report.

Progress toward performance measures will be included in quarterly progress reports. The actual number of samples collected/analyzed and reports completed will be compared to the expected number.

Site Description

Monitoring sample collection for this project will occur throughout the legal boundaries of the Sacramento-San Joaquin Delta (Delta). The Delta drains approximately 40% of the land area in California as it enters the San Francisco Bay. Historically, the Delta was characterized by extensive tidal and seasonal wetlands, but much of this landscape has now been significantly altered. Much of this region has been diked and drained, resulting in an increase in agricultural and urban landscapes. Many natural waterways have been altered or constructed to provide deep-water navigation channels, improve water circulation, or obtain material for levee construction. Additional projects are currently being considered that could substantially alter hydrological conditions even further, impacting mercury transport and cycling. Substantial efforts are also being made to restore wetlands areas, including a commitment by the California EcoRestore program to restore 30,000 acres of wetlands. Studies have shown that wetlands can act as MeHg sources (St. Louis et al., 1996; Galloway and Branfireun, 2004; Heim, 2011). Long-term mercury monitoring will help document the impacts of these continuing hydrologic and habitat changes in the Delta on mercury levels of exposure risks.

Today the Delta covers about 1,153 square miles, including 841 square miles (538,000 acres) of agriculture, 100 square miles (64,000 acres) of urban uses, 95 square miles (61,000 acres) of water surface, and 117 square miles (75,000 acres) of undeveloped land, as well as about 1,100 miles of leveed channels. The Delta MeHg TMDL delineates 7 subregions (distinct from the State Water Board's 303(d) listing segment delineations) that experience different MeHg sources and levels of fish impairment (see project map and monitoring site description attachments).

Background and Conceptual Models

Mercury contamination is one of the most significant water quality issues affecting the health of humans and wildlife in the Bay-Delta (Greenfield et al., 2005; Gassel et al., 2008; Davis et al., 2008; Ackerman and Eagles-Smith, 2010; Wood et al., 2010). The combination of coastal ranges that contain mercury ores and the use of mercury in historic mining operations have resulted in significant mercury concentrations in the Delta (Hornberger et al., 1999; Churchill, 2000; Domagalski, 2001; Heim et al., 2007). Under anaerobic conditions, bacteria transform mercury into its more toxic form, MeHg, which is bioavailable and then transferred up the food chain (Compeau and Bartha, 1985; Gilmour and Riedel, 1995; Gilmour et al., 1996).

Both the Central Valley and the San Francisco Bay Regional Water Quality Control Boards have classified the Delta and Bay as impaired due to elevated mercury levels and have developed TMDL control plans to reduce the impairment (Wood et al., 2010). Other actions are also underway or being contemplated in the Delta that could affect MeHg accumulation in the food web, including large-scale habitat restoration and hydrological alterations. In addition, recent research suggests that nutrients may also be a factor in the production of methylmercury and demethylation of mercury by bacteria (Liem-Nguyen et al 2016). Understanding of interannual trends of mercury in different regions of the Delta is urgently needed to track the impacts of these management actions on mercury contamination.

The key management plan for mercury in the Delta is the MeHg TMDL (Wood et al, 2010). The TMDL articulates a conceptual model for MeHg in the Delta that provides the foundation for the control plan. The conceptual model is based on extensive monitoring and research, largely funded by the CALFED Ecosystem Restoration Program in the 2000s (see Figure 1). This work led to the development of a Mercury Strategy for monitoring, research, risk communication, and adaptive management to address mercury problems in the Bay-Delta system (Weiner et al. 2003). A fundamental feature of the conceptual model is an observed linkage between MeHg concentrations in water and the concentrations in predator fish (especially largemouth bass) that represent the primary indicator of impairment (and the water quality objective) (see Figure 2). However, the relationship between MeHg concentrations and production in sediment and MeHg concentrations in water and fish is not well understood, and represents a key gap in the TMDL conceptual model that can be filled in part through this monitoring project.

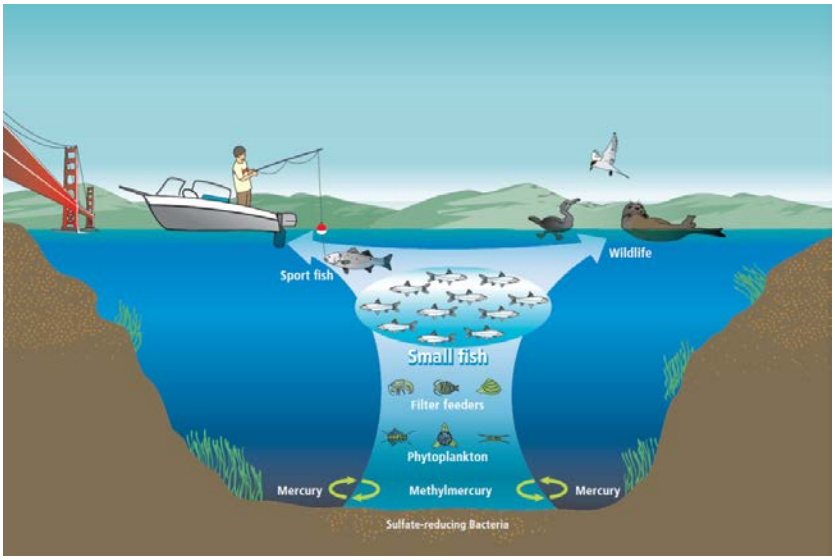


Figure 1. Conceptual model of bioaccumulation of methylmercury

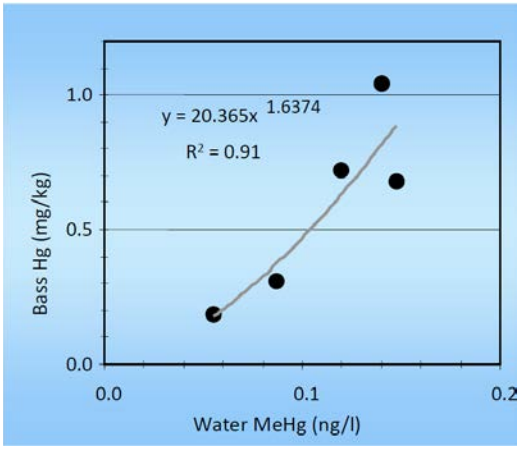


Figure 2. Relationship between standard 350-mm largemouth bass MeHg and March to October 2000 unfiltered aqueous methylmercury. The TMDL target concentration for standard 350-mm largemouth bass is 0.24 mg/kg.

Spatial patterns in sport fish MeHg in the Delta have been fairly well-characterized, but very few data are available on interannual variation and long-term trends. Sampling at seven locations in the Delta by the Surface Water Ambient Monitoring Program in 2011 (Davis et al. 2013) confirmed the spatial pattern observed in previous surveys going back to 1998 (Davis et al. 2003, Davis et al. 2008, Melwani et al.

2009), with high concentrations around the edges of the Delta and low concentrations in the central Delta. The concentrations around the periphery of the Delta exceed safe levels for wildlife determined by the US Fish and Wildlife Service (Woods et al. 2010).

Time series of repeated measurements at specific Delta locations are lacking. The best time series available are far from ideal due to inconsistencies in sampling location, sample sizes, size ranges, and species, but do suggest consistent concentrations over time, with relatively high concentrations at the sites around the northern periphery of the Delta (ranging between approximately 0.60 and 0.80 ppm wet weight), and lower concentrations at the locations in the central Delta (ranging between approximately 0.20 and 0.30 ppm). Time series based on repeated, directly comparable measurements are needed for an accurate characterization of long-term trends. Rigorous trend monitoring of Delta sport fish will be an essential performance measure for evaluation of the effectiveness of the MeHg TMDL (Wood et al. 2010).

In keeping with the conceptual model developed for the MeHg TMDL, the proposed fish sampling would focus on the main impairment indicator specified in the TMDL (largemouth bass). Largemouth bass are also appropriate to facilitate comparisons with prior data that was collected. In addition, largemouth bass are excellent indicators because they have high site fidelity and a high trophic position in the Delta food web.

The sampling design for largemouth bass includes analysis of mercury in individual fish. An analysis of covariance approach (ANCOVA) will be employed where possible, in which the size:mercury or age:mercury relationship will be established for each location and an ANCOVA will be performed. The ANCOVA will allow evaluation of differences in slope of the regression relation among the locations and comparison of mean concentrations and confidence intervals at a standardized total length, following the approach of Tremblay (1998). Experience applying this approach in past sampling indicates that to provide robust regressions, 11 fish spanning a broad range in size are needed to represent each unique sampling location and time (Davis et al. 2003). Annual sampling will be performed at 6 fixed stations, including 11 largemouth bass per station that have been selected for long-term monitoring.

The MeHg TMDL also established a water concentration implementation goal of 0.06 ng/L unfiltered MeHg. Monitoring of water concentrations to track performance relative to this goal will provide a valuable tool for managing MeHg discharges to the Delta and for understanding processes leading to accumulation in fish and impairment. Quarterly water sampling will be conducted at 6 stations that are co-located with the fish monitoring and to provide information that will be useful input to the mercury model in development for the Delta by DWR. The paired fish and water data will allow further assessment of the strength of the correlation between these two matrices. Ancillary water parameters will be collected to aid in interpretation of the MeHg data.

A key variable in the conceptual model is the concentration of MeHg in sediment and the relationship between MeHg production in sediment and corresponding concentrations in the overlying water and fish. The impact of restoration projects on the production of MeHg is a critical question. Quarterly sediment sampling will be conducted at the same 6 fixed stations to begin filling these data gaps. It will be important to understand the relationship between areas of high MeHg production in sediment and concentrations of MeHg in co-located fish and water samples. Understanding the mechanisms of methylation and MeHg uptake will be informative as habitats are restored in the Delta.

Scientists at the Department of Water Resources (DWR) have indicated that sediment mercury data will be critical for the support of the DWR Delta Mercury model that is under development for the Yolo Bypass and Delta. Currently available sediment mercury data for the Delta were collected in the early 2000s and collecting new samples to identify spatial and temporal patterns in Delta mercury will be critical to model calibration.

Approach and Statement of Work

The study plan in this proposal was developed as part of the planning process for the Delta RMP. The Steering Committee and Technical Advisory Committee with representatives from the Central Valley Regional Water Quality Control Board, USEPA, California Department of Water Resources, the State and Federal Contractors Water Agency, and various discharger groups collaboratively developed and prioritized management questions for the Delta RMP as a whole and specific management questions for priority topics such as mercury. A mercury workgroup consisting of regional mercury experts and stakeholders then developed the monitoring plans to address the management questions. The study plan for fish and water monitoring is outlined in a comprehensive Monitoring Design: http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_regional_monitoring/wq_monitoring_plans/drmp_monitoring_design.pdf. CDFW funding would support the addition of sediment monitoring to this design fill a key data gap in the current Delta MeHg TMDL conceptual model.

The Delta RMP has been able to begin implementation of mercury monitoring in FY16/17 (July 1, 2016); however, it is not guaranteed that the Program will be able to continue monitoring mercury every year for the next few years as the Program seeks to balance many scientific needs with the existing budget. CDFW funding would support implementation of this monitoring program in FY17/18, FY18/19, and the first half of FY19/20. Data synthesis and development of a technical report will occur in 2020.

CONTRACTOR (ASC) WORK TASKS

1. Project Management and Administration
    a. Establish and manage subcontract with Moss Landing Marine Laboratory
    b. Prepare for quarterly Steering Committee, quarterly Technical Advisory Committee meetings, and annual Mercury Workgroup meetings to convene stakeholders, regulators and scientific experts to provide feedback on project progress and direction.
    c. Prepare quarterly invoices to the funding entity
    d. Prepare quarterly progress reports to the funding entity
    e. Prepare annual reports to the funding entity
    f. Prepare Close-Out Summary Report accounting for all deliverables and expenses.

    This task will be completed with Cost Share Funds from the Delta RMP ($20,000 estimated).
2.– 4. Collection and Analysis of Fish, Water and Sediment
    a. See Subcontract section.
5. Data Management
    b. Perform QA/QC review on each annual dataset for mercury in water, sediment and fish samples. Prepare an annual Quality Assurance Report documenting QA/QC metrics and samples analyzed for each data set.
    c. Upload water, sediment and fish collections and analytical data to CEDEN at end of each year following grant agreement execution.

    The task will be completed with Cost Share Funds from the Delta RMP ($74,000 estimated).
6. Data Reporting
    a. Analyze fish data collected during FY 17-18, together with water, and fish data collected prior to the grant term in FY 16-17. Publish data and analyses in the 2018 Pulse of the Delta.
    b. Synthesize water, sediment and fish data collected during the first 2.5 years of the grant term (FY 17-18, FY 18-19, and the first half of FY 19-20), together with water and fish data collected prior to the grant term in FY 16-17. Statistical analyses of the data will be conducted by ASC using a software program such as R. Graphical representation of the data will be conducted using excel or R. Collaborate with Subcontractor to prepare a

Final Report on results of mercury monitoring in water, sediment and fish tissue samples. A draft of the Final Report will be distributed to CDFW and Delta RMP stakeholders 90 days before the end of the grant term. The draft report will focus primarily on data collected during FY 16-19 (including the first two years of the grant term). Results from the final year of sampling will be included in the final report, which will be distributed prior to the end of the grant term. Additional analyses of the data are expected to be published in the 2020 Pulse of the Delta.

c. Provide water and sediment data to the DWR Delta Hg modeling group.

The task will be completed with Cost Share Funds from the Delta RMP ($50,000 estimated).

SUBCONTRACTOR (MLML) WORK TASKS

The field and analytical work for this project will be conducted by the Marine Pollution Studies Lab (MPSL) at Moss Landing Marine Laboratories (MLML) in Moss Landing, California. MLML has a fleet of trucks and boats (including 3 electroshocking). Multiple boats are set up to accommodate the hydraulic winch and davit system necessary to collect water and sediment samples according to the methods stated below. MLML has both general and specialized laboratory space including a class-100 clean laboratory for sample handling and processing, 3 dedicated mercury laboratories, a dedicated trace element analytical laboratory equipped with an Inductively coupled plasma mass spectrometry instrumentation, a dedicated class-100 clean acid washing laboratory, and a dedicated class-100 clean laboratory with refrigeration capability for conducting constant temperature laboratory studies. Additional details can be found at: http://mpsl.mlml.calstate.edu/mpsl-dfg.

MLML has developed trace metal methods for measuring mercury speciation in fish tissue, water, and sediment and has been involved with the State Surface Water Ambient Monitoring Program (SWAMP) since 2001. In addition, this laboratory has collected and analyzed water, sediment and fish tissues for many CAL-FED and Ecosystem Restoration programs.

MLML has participated in multiple interlaboratory exercises including those conducted by the CALFED Mercury Program, State of Florida Department of Environmental Protection, and Brooks Rand Labs. MLML resultsin interlaboratory studies are consistently in the top tiers. Furthermore, MLML analytical results consistently exceed the quality assurance and quality control requirements outlined in the SWAMP Laboratory Quality Assurance Program Plan.

Finally, MLML has been audited to assess mercury analytical abilities as a requirement for participation in both the federal and California state sponsored CALFED Mercury Program and SWAMP. Audits concluded: 1) MLML laboratory's preparation and analytical spaces are more than sufficient for the utilized methods and SOPs; 2) Instrumentation and equipment is current, and in many cases, state-of-the-art; 3) staff expertise and retention are outstanding; and 4) QA systems implemented at MLML have greatly benefitted SWAMP, and are certainly worthy of federal and state-level certifications.

1. Project Management and Administration
    a. Prepare Field Sampling Plan
    b. Prepare quarterly progress reports for ASC to provide to the funding entity
    c. Prepare quarterly invoices to ASC
2. Collection and Analysis of Fish
    a. Obtain Scientific Collection Permit – Application submitted June 2016, expected to be approved in 2016. The permit will be renewed in 2019.
    b. Collect fish samples annually for three years (FY 17-18, FY 18-19, FY 19-20). Largemouth bass (or similar predator species) will be collected at six fixed locations in the Delta each year. At each location, 11 individual bass or predator fish will be collected and analyzed for total mercury. The indicator of primary interest will be MeHg in muscle

fillets of largemouth bass (or similar predator species). For cost savings and given >95% of mercury in fish muscle tissue is MeHg, total mercury will be measured and used as a proxy for MeHg (Bloom 1992).

Fish habitats in the Delta vary greatly, and there is no one method of collection that is appropriate for all species and size classes. Potential sampling methods can be found in MPSL standard operating procedure MPSL-102a Tissue Collection. These methods include, but are not limited to, electroshocking, seining, and gill netting. The field collection crew will determine the appropriate collection method based on physical site parameters such as depth, width, flow and accessibility.

Collected fish may be partially dissected in the field. At the dock, the fish is placed on a measuring board covered with clean aluminum foil; fork and total length are recorded. Weight is recorded. Fish will then be placed on the cutting board covered with aluminum foil where the head, tail, and guts are removed using a clean cleaver (scrubbed with Micro™, rinsed with tap and deionized water). The fish cross section is tagged with a unique numbered ID, wrapped in aluminum foil, and placed in a clean labeled bag. When possible, parasites and body anomalies are noted. The cleaver and cutting board are re-cleaned with Micro™, rinsed with tap and deionized water between fish species, per site if multiple stations are sampled.

c. Enter field data in CEDEN templates and deliver to Contractor after each sampling event
d. Process fish samples using appropriate compositing techniques.
   Fish samples are prepared for analysis in the laboratory in accordance with MPSL-105. Sport fish are dissected filet only, skin off, for mercury analysis. No homogenization is necessary because mercury is evenly distributed in the filet muscle.
e. Analyze processed samples using appropriate laboratory techniques
   Tissue samples for total mercury will be analyzed according to EPA 7473, “Mercury in Solids and Solutions by Thermal Decomposition, Amalgamation, and Atomic Absorption Spectrophotometry” (USEPA 1998) using a Direct Mercury Analyzer (DMA 80)
f. Prepare and analyze all necessary quality control samples, such as laboratory duplicates, matrix spikes and certified reference material samples, as specified in the Delta RMP QAPP, for mercury using appropriate laboratory techniques (e.g., EPA Method 7473). Samples, blanks, and standards will be prepared using clean techniques. ASTM Type II water and analytical grade chemicals will be used for all standard preparations. A continuing calibration verification (CCV) will be performed after every 10 samples. Initial and continuing calibration verification values must be within ±20% of the true value, or the previous 10 samples must be reanalyzed. Three blanks, a certified reference material (NRCC DORM-3 or similar for fish), as well as a method duplicate and a matrix spike pair will be run with each analytical batch of samples.
g. Enter laboratory data in CEDEN templates and provide data and case summary to the Contractor at the end of each sampling year.

3. <u>Collection and Analysis of Water</u>
   a. Collect water samples from 6 sites quarterly for 2.5 years (FY 17-18, FY 18-19, and the first half of FY 19-20; 60 site visits total) plus quality control samples such as field duplicates and field blanks. Water will be analyzed for unfiltered and filtered total mercury and methylmercury, suspended solids, volatile suspended solids, chlorophyll a, and dissolved organic carbon. In addition, measurement of temperature, pH, conductivity, and dissolved oxygen will be made using a multi-parameter probe.

   Water samples will be collected following methods described in U.S. Geological Survey Techniques of Water-Resources Investigations Book 9, Chapter A5 (Version 1.0, 10/2004). Briefly, water samples will be collected using an isokinetic sampler to collect a depth integrated cross channel water sample. Samples will be collected using clean hands/dirty hands techniques.

b. Enter field data in CEDEN templates and deliver to Contractor at the end of each sampling year.
c. Analyze water samples using appropriate laboratory techniques.
    i. Unfiltered and filtered aqueous methylmercury will be analyzed according to EPA 1630.
    ii. Unfiltered and filtered total mercury will be analyzed according to EPA 1631 Rev E.
    iii. Ancillary Measurements
        1. Water column chlorophyll *a* - EPA Method #:445.0
        2. Suspended Sediment Concentration – MPSL Method #: 108
        3. Grain Size- Standard Method
        4. Dissolved Organic Carbon – EPA Method #: 415.1
        5. Volatile Suspended Solids - MPSL Method #: 108
d. Prepare and analyze all necessary quality control samples such as laboratory duplicates, matrix spikes, and certified reference material samples as specified in the QAPP
e. Samples, blanks, and standards will be prepared using clean techniques. ASTM Type II water and analytical grade chemicals will be used for all standard preparations. A continuing calibration verification (CCV) will be performed after every 10 samples. Initial and continuing calibration verification values must be within ±20% of the true value, or the previous 10 samples must be reanalyzed. Three blanks, a certified reference material, as well as a method duplicate and a matrix spike pair will be run with each analytical batch of samples.
f. Enter laboratory data in CEDEN templates and provide data and case summary to the Contractor at the end of each sampling year.

4. <u>Collection and Analysis of Sediment</u>
    a. Collect sediment samples from 6 sites quarterly for 2.5 years (FY 17-18, FY 18-19, and the first half of FY 19-20; 60 site visits total). At each site a sediment sample will be collected from the thalweg and shoal. Sediment will be analyzed for total mercury, methyl mercury, total organic carbon, acid volatile sulfide, and grain size.
    Sediment samples will be collected according to MPSL-102b Sediment Collection, section 7.3, using either a Van Veen or Eckman Grab. The top 2 centimeters of material is transferred to a clean sample container. A 2 inch polycarbonate core will be used in conjunction with the grab sample to transfer surficial sediment from the grab to sample container. Sediment samples for mercury and organic carbon will be kept frozen on dry ice during transport to MLML. Grainsize samples will be kept on wet ice during transport to MLML.
    b. Enter field data in CEDEN templates and deliver to Contractor at the end of each sampling year.
    c. Analyze sediment samples using appropriate laboratory techniques.
        i. Sediment samples for total mercury will be analyzed according to EPA 7473, “Mercury in Solids and Solutions by Thermal Decomposition, Amalgamation, and Atomic Absorption Spectrophotometry” (USEPA, 1998) using a Direct Mercury Analyzer (DMA 80).
        ii. Sediment samples for methylmercury will be extracted following MPSL-110 Methyl Mercury in Sediments by Acidic KBr Extraction into Methylene Chloride. After extraction, the samples may then been analyzed as aqueous samples and analyzed according to modified EPA 1630, “Methyl Mercury in Water by Distillation, Aqueous Ethylation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry” using a Tekran 2600.
        iii. Total organic carbon, acid volatile sulfide, and grain size measurements will be made using standard accepted methods.

   d. Prepare and analyze all necessary quality control samples such as laboratory duplicates, matrix spikes, and certified reference material samples as specified in the QAPP. Samples, blanks, and standards will be prepared using clean techniques. ASTM Type II water and analytical grade chemicals will be used for all standard preparations. A continuing calibration verification (CCV) will be performed after every 10 samples. Initial and continuing calibration verification values must be within ±20% of the true value, or the previous 10 samples must be reanalyzed. Three blanks, a certified reference material, as well as a method duplicate and a matrix spike pair will be run with each analytical batch of samples.
   e. Enter laboratory data in CEDEN templates and provide data and case summary to the Contractor at the end of each sampling year.
5. Data Management
   a. See Contractor Section
6. Data Reporting
   a. Prepare Annual Field Sampling Reports that document the samples collected during the field season and any deviations from the sampling plans and Delta RMP QAPP.
   b. Synthesize water, sediment and fish data collected during the first 2 years of the grant term, together with water and fish data collected prior to the grant term in FY 16-17. Collaborate with Contractor to prepare a Final Report on results of mercury monitoring in water, sediment and fish tissue samples. A draft of the Final Report will be distributed to CDFW and DRMP stakeholders 90 days before the end of the grant term. Results from the final year of sampling will be included in the final report, which will be distributed prior to the end of the grant term. Additional analyses of the data are expected to be published in the 2020 Pulse of the Delta.
   c. Provide water and sediment data to the DWR Delta Hg modeling group.

Tasks 2,3, and 4 are independent monitoring tasks. Tasks 1,5, and 6 are core tasks that are essential to fully executing the planning, analysis, and distribution of data collected during tasks 2-4.

In addition, the Delta RMP has a number of proven methods to communicate project findings to a wide audience as described below.

- Preliminary results will be discussed in the quarterly Technical Advisory Committee and Steering Committee meetings which are attended by local, state and federal agencies as well as important stakeholders such as water purveyors, agricultural coalitions, stormwater agencies and wastewater treatment facilities.
- All of the data from this project will be uploaded to CEDEN (see Data Management section). In addition, all of the reports from this project will be posted on the Central Valley Regional Water Quality Control Board site (http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_regional_monitoring/index.shtml)
- The Delta RMP has produced an award-wining glossy report (the Pulse of the Delta) that provides a high-level of synthesis and overview and is designed to be read by a wide audience (http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_regional_monitoring/studies_reports/2012_pulseofthedelta.pdf). It is anticipated that the findings from this project will be incorporated into the Fall 2018 and Fall 2020 Pulse of the Delta as articulated in the Delta RMP Communications Plan.
- ASC has several very active social media sites and frequently disseminates relevant scientific studies through the SFEI website (http://www.sfei.org/DeltaRMPTechSupport#sthash.UypHj2aK.inxTJ9zN.dpbs) and Twitter.

- ASC routinely present recent scientific findings at local (San Francisco Bay Delta Science Conference, NorCal SETAC), state (SWAMP roundtable meetings, Mercury workgroups (Bay RMP, Delta Science, etc.), national meetings (Society for Environmental Toxicology and Chemistry) and international meetings (International Conference on Mercury as a Global Pollutant – Rhode Island 2017). It is likely that a scientific presentation or poster will be given on this project at one or more of these conferences.

Feasibility

The proposed project will support the completion of years 2 through 4 (FY 17-18, FY 18-19, and FY 19-10) of a long-term monitoring program in the Delta that was developed through a stakeholder-driven planning process within the Delta RMP. The study design for this project was developed through a Mercury subcommittee composed of regional stakeholders and mercury experts. The first year of monitoring was funded by the Delta RMP in FY 16-17.

The Delta RMP is collaborative monitoring program comprised of both local stakeholders and regulators (including regional, state and federal representatives), and is uniquely positioned to support this work and ensure the impactful dissemination of the resulting data and analyses. The Delta RMP is currently in its second year of operation, and has established a regular process for long-term financial and scientific planning, as well as a formal quality assurance program plan and communications plan. The robust governance infrastructure of the Delta RMP – which includes quarterly Steering Committee and Technical Advisory Committee meetings, and annual subcommittee meetings advised by scientific experts – will support programmatic and scientific oversight of project progress and ensure rapid resolution to financial, logistical or scientific questions. Furthermore, this project can take advantage of the Delta RMP's larger scientific monitoring program, including a major focus on monitoring nutrients, which may influence the cycling of MeHg in sediments (Liem-Nguyen, et al. 2016).

During FY 16-17, the project team will implement the first year of water and fish monitoring using a monitoring design similar to that described in the current proposal. This work has already included the approval of a Scientific Collections Permit, a quality assurance project plan, and field sampling plans. These products, together with subsequent field experience at the planned sampling locations, will help minimize project delays in future sampling years during the grant term.

ASC is the Implementing Entity for the Regional Monitoring Program for Water Quality in San Francisco Bay (http://www.sfei.org/rmp), the Klamath Basin RMP (http://www.kbmp.net/) and the Delta RMP. In this capacity, ASC manages over $4,000,000 of regional monitoring funding each year. ASC/SFEI has close to 25 years of regional monitoring experience completing high quality scientific investigations that have a high impact for management of the Bay-Delta (e.g. ASC's Fish Mercury Project in the Bay-Delta –http://www.sfei.org/sites/default/files/biblio_files/Final_FMP_2006_Sport_Fish_Technical_Report.pdf), and high profile (e.g., California sport fish survey reporting mercury results as published in San Francisco Chronicle (http://www.sfgate.com/science/article/California-sport-fish-survey-mercury-PCBs-higher-3585901.php). In addition, ASC has a proven track record of managing large multifaceted programs with multiple subcontractors, assuring on-time and within budget deliverables.

The field collections for this project will be conducted by staff of the Marine Pollution Studies Lab (MPSL) at Moss Landing Marine Laboratories (MLML) in Moss Landing California. MLML staff has extensive experience in proper collections of fish, sediment, and water for trace metal and contaminants work. MLML has a number of small boats including three electro shocking boats and trucks to trailer boats, and specific sampling equipment for collection of fish, water, and sediment. The analytical work for this project will be conducted at MLML. MLML is a long established analytical laboratory with decades of experience analyzing trace metal samples (including mercury) for projects such as State

Mussel Watch, CALFED Mercury Projects, and SWAMP. MLML routinely participates in round robin inter-laboratory comparisons and passes with highest scores attainable. MLML also undergoes laboratory audits as a participant in the SWAMP program. MLML has both general and specialized laboratory space including a class-100 clean laboratory for sample handling and processing, three dedicated Hg laboratories, a dedicated trace element analytical laboratory equipped with an Inductively coupled plasma mass spectrometry instrumentation, a dedicated class-100 clean acid washing laboratory, and a dedicated class-100 clean laboratory with refrigeration capability for conducting constant temperature laboratory studies. Additional details can be found at: https://mpsl.mlml.calstate.edu/mpsl-dfg.

Climate Change Considerations

Climate change has the potential to substantially impact on both water flows and water quality in the Delta – both directly through reduced water inflows to the Delta and increased water temperatures, and indirectly through changes in human water consumption and land use patterns in response to climate change. These processes in turn may have a significant impact on mercury cycling, bioaccumulation, and exposure risk in the Delta. Monitoring results produced by this project will provide a baseline assessment of current mercury conditions in the Delta, which together with monitoring conducted in future years, will provide information necessary to understand how climate change is affecting water quality in the Delta and subsequent impacts on the Delta ecosystem.

Overall, the Bay-Delta region is expected to get hotter and drier, and experience more extreme precipitation events and reduced water storage in snowpack. By 2100, temperatures in the Bay-Delta region are expected to increase between 1.5 – 4.5 ^{0}C, while average annual rainfall is projected to decrease between 7.6 to 12.7 cm. As a result, estuarine flows are expected to decrease about 20% from current levels between March and September (PRBO 2011; Cayan et al. 2011 as cited in CDFW 2015; Cloern et al. 2011)**.** At the same time, infrastructure projects are already being considered that may substantially alter flows in the Delta in order to export additional freshwater resources for human municipal and agricultural use, potentially resulting in overall lower freshwater flows. Lower flow volumes and velocities during the spring and summer months could cause the contaminants to become concentrated. In addition, water temperatures are likely to increase as well. These factors may increase the likelihood of anoxic sediment conditions that facilitate MeHg production. At the same time, more extreme precipitation events are expected, along with higher flow and flood frequencies in the winter months as precipitation begins to fall as rain rather than snow. These more flashy precipitation processes could contribute to increased mercury loading from the surrounding watershed during winter months, as well as increased MeHg fluxes from within-Delta and floodplain sediments. Flood conditions could similarly encourage MeHg production under anoxic conditions. Less well understood, but just as likely to impact mercury cycling, changes in habitat availability and species ranges due to changing flows, temperatures, and salinity intrusion will alter current patterns of cycling and bioaccumulation, as well as the spatial distribution of mercury exposure risk in both wildlife and humans (Cloern et al. 2011).

While mercury monitoring efforts have previously taken place in the Delta, the data have been produced across multiple disjointed projects. The proposed project will be the first coordinated effort to conduct systematic, long-term monitoring that will result in easily comparable measurements that can be used to assess how mercury levels and cycling have changed as a result of climate change impacts. The first year of monitoring will have begun in FY 16-17. These grant funds will ensure that monitoring can continue as soon as possible, enabling climate change-related trends to be more fully captured. Current monitoring might also allow for an analysis of mercury response to drought conditions, which are more likely to be experienced under future climate change scenarios.

Data produced by this project will also play a key role in further informing and refining both the mercury conceptual model in the Delta MeHg TMDL, and coupled hydrodynamic and water quality computer models such as those being developed by the Department of Water Resources and Reed Harris, Environmental, Ltd. These models will enable scenario testing to predict the impacts of changing environmental conditions such as tributary flows, air and water temperature, sediment dynamics, or reservoir and water conveyance operations on mercury transport and cycling – a particularly valuable tool as the impact of various climate change regimes on many of these factors is not well understood. This key ability will facilitate efforts to identify potential causes of future water quality degradation under climate change conditions and mitigate impacts on ecosystem services and mercury exposure to humans and wildlife.

Schedule & Deliverables

Tasks 2-5 recur on an annual basis for each sampling year. Due dates are provided for each deliverable and project milestone

Task No.	Task Title	Deliverables and Key Project Milestones	Estimated Completion Dates
1	Project Management and Administration	• Executed Subcontractor Contract and Scope of Work • 16 Quarterly Subcontractor Progress Reports to Contractor • 16 Quarterly Invoices to Funding Entity • 16 Quarterly Project Progress Reports to Funding Entity • 3 Annual Project Reports to Funding Entity • Close-Out Summary report to Funding Entity • Field Sampling Plan	• July 30, 2017 • Due within thirty (30) days following each quarterly month following Agreement execution. • Due annually each year following Agreement execution • Due thirty (30) days prior to end of grant term • July 30, 2017, 2018, 2019
2	Collection and Analysis of Fish	• Obtain Scientific Collection Permit • Renew Scientific Collection Permit • Fish Samples Collected • Annual Fish Data & Case Summaries to Contractor	• July 1, 2017 (expected to be approved by 2016) • July 1, 2019 • November 30, 2017, 2018, 2019 • April 30, 2018-19; March 31, 2020
3	Collection and Analysis of Water	• Water Samples Collected • Water Data & Case Summaries to Contractor	• June 30, 2018-19; December 31, 2019 • October 31, 2018-19; March 31, 2020

4	Collection and Analysis of Sediment	• Sediment Samples Collected • Sediment Data & Case Summaries to Contractor	• June 30, 2018-19 December 31, 2019 • October 31, 2018-19 March 31, 2020
5	Data Management	• Quality Assurance Report (fish samples) • CEDEN upload of fish samples • Quality Assurance Report (water and sediment samples) • CEDEN upload of water and sediment samples	• July 31, 2018-19; June 30, 2020 • Aug 31, 2018-19; June 30, 2020 • December 31, 2018-19; June 30, 2020 • Jan 31, 2019-2020; June 30, 2020
6	Data Reporting	• 3 Annual Field Sampling Reports (fish, water, sediment) • Interim Analysis of FY 17-18 fish data for inclusion in the 2018 Pulse of the Delta Report • Draft Synthesis Report on Sampling during FY 16-19 • Final Synthesis Report (including sampling during FY 19-20) • Provide data to DWR Delta mercury modeling group	• August 31, 2018-19, February 28, 2020 • October 31, 2018 • March 31, 2020 • June 30, 2020 • Jan 31, 2019-2020; June 30, 2020

Community Support and Collaboration

The Delta Regional Monitoring Program (Delta RMP) is one of the priority actions of the Bay-Delta Strategic Workplan, which responds to a joint resolution of the State Water Board and the Central Valley and San Francisco Bay Regional Water Boards. The Delta RMP is a collaborative stakeholder effort to provide improved Delta monitoring and data evaluation.

The Delta RMP Steering Committee (SC) has established guidelines, roles and responsibilities, and funding for this monitoring program, and has established the ASC as the implementing agency. The decision-making body of the Delta RMP is the SC, which is comprised of representatives from Federal and State regulatory agencies (USEPA/Central Valley Water Board/NOAA Fisheries), wastewater treatment facilities, storm water agencies, irrigated agriculture coalitions, water suppliers, and coordinated monitoring programs (e.g., Interagency Ecological Program). The SC meets quarterly to prioritize information needs, to provide input on program activities, to review program deliverables, and to conduct long-term strategic planning.

The Delta RMP has also established a Technical Advisory Committee (TAC), which is similarly comprised of representatives from regulatory agencies and stakeholder groups represented in the Steering Committee, as well as technical experts. The TAC meets quarterly to provide oversight into the technical quality of Delta RMP projects, including developing, reviewing, and revising the Delta RMP's monitoring studies, and providing technical review of the planning, development and publication of Delta

RMP reports. As needed the Delta RMP has specialized subcommittees advising the Technical Advisory Committee; these subcommittees are comprised of regional and national experts. The lead for the Mercury Delta RMP subcommittee is Dr. Jay Davis of SFEI/ASC.

Almost all of the stakeholder groups participating in the Delta RMP provide financial contributions to the RMP totaling over $1,000,000 (the budget for FY16/17 is $1,043,000). All of the participating stakeholder groups also provide in-kind contributions in terms of staff time to assist with the oversight and management of the Delta RMP. Stakeholders participate in quarterly SC and TAC meetings, subcommittee meetings on specific issues (e.g., mercury, nutrients, pathogens or pesticides/toxicity); review Delta RMP products and provide guidance to staff. In addition, in FY16/17, the Delta RMP is receiving over $270,000 in matching funds from external partners for sample collection and laboratory analyses (i.e., USGS, Moss Landing Marine Laboratories, and State SWAMP funds).

For this project, it is expected that the Delta RMP Steering Committee will approve funding for a three year period for project management, data management, and report writing for mercury monitoring in the amount of $144,000, a cost share that has been authorized by the Delta RMP co-chairs. The Steering Committee will also commit nearly $2,100,000 for related monitoring in the Delta over the three year period of this proposal. This financial commitment by a variety of stakeholders shows wide spread public and institutional support for the project and a concerted effort to include stakeholders every step of way in the project planning, design, implementation, and outreach/education activities.

Additionally, data generated through this monitoring effort will play a key role in the development a mercury cycling model that will give managers tools to evaluate the influences of changes in operational conditions on MeHg trends. This model also has the potential to be expanded and used by other stakeholders to evaluate MeHg trends associated with other activities such as wetlands restoration. The Department of Water Resources has collaborated with the Delta RMP in developing this mercury monitoring design, and their modeling work will ensure that the data from this project will continue to have significant impacts on management decisions throughout the Delta.

As testimony to the value of this project and collaborative nature of the program, included with this proposal are two letters of support from the Central Valley Regional Water Quality Control Board and the Department of Water Resources.

More information about stakeholder involvement in Delta RMP projects can be found here: http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/comprehensive_monitoring_program/delta_rmp_committee_roles.pdf

Data Management and Access

The Delta RMP has developed procedures for sample collection, data management and reporting including a Quality Assurance Program Plan (QAPP), Monitoring Design Summary, and Communications Plan. These documents have been reviewed by the Delta RMP TAC and SC. In addition, the QAPP was reviewed and approved by the SWAMP QA Officer and Database Manager in March 2016. With the inclusion of mercury monitoring into the program, the QAPP is currently being revised and will be resubmitted for approval by the SWAMP QA Officer in the summer of 2016.

Monitoring data collected during this project will be formatted, validated using the procedures outlined in the QAPP and uploaded to the California Environmental Data Exchange Network (CEDEN) by the Aquatic Science Center data management staff using cost share funding (estimated value $74,000). Uploading this data to CEDEN will also support visualization of the data through the publically available California Estuaries Portal.

The Aquatic Science Center/ San Francisco Estuary Institute has significant experience managing data; it is one of the state's Regional Data Centers that exchanges water quality data to CEDEN. In addition, approximately one third of the institute's staff is involved with the Environmental Informatics Program that uses the latest technology and design concepts to deliver scientific information through such web-based tools such as EcoAtlas, California Rapid Assessment Method, and the Contaminant Data Display and Download tool (CD3).

The Aquatic Science Center/ San Francisco Estuary Institute contributes over 1.1 million data points to the CEDEN database with more than 550,000 sample results available to map and download using the CD3 tool; the Institute has developed interactive maps to display sediment, water and tissue data by analyte and station for the Bay RMP and also includes data from many other projects and agencies. Additional overlays to the base map are available including hydrology, ecoregion, etc. Temporal trends and statistical information (e.g., box and whisker plots, quantile/quartile, histograms, etc.) can be displayed for sites with long-term monitoring. The data and mapping tool is publically available and widely used by scientists, regulators, water quality managers, and the public. It is anticipated that because the Delta RMP collects data, similar data visualizations will be made available. All of the Delta RMP data (e.g., pesticides, pathogens, mercury, etc.) will be available to the public through CEDEN.

Data will be uploaded to CEDEN and subsequently distributed no later than six months after the end of each sampling year (i.e., December 2018, December 2019, and June 2020 for each sampling year of the project, respectively). All data collected during the grant term will be distributed prior to the end of the three year grant term. These publically available data can then be used to inform further research and state regulatory efforts, including the Department of Water Resources Delta Mercury model and the Delta MeHg TMDL.

All reports, including field sampling plans, sampling reports, and analyses of monitoring results will be reported quarterly to the Delta RMP Steering Committee and Technical Advisory Committee, and posted on the Delta RMP website (http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/comprehensive_monitoring_program/index.shtml).

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